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SPACING STAKED TOMATOES¹

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An experiment to determine the optimum distance for planting staked tomatoes was carried out at the Dominion Experimental Farm, Agassiz, B.C., from 1935 to 1938 inclusive. Previous experiments had been conducted on methods of pruning by which it was determined that plants trained to a single stem gave the most satisfactory results (1).

METHODS AND MATERIALS

The variety used each year was the Bonny Best. The soil is classified as a Monroe clay loam and was each year fertilized with approximately 40 tons of barnyard manure. No other fertilizer was used and plants grew under natural conditions of moisture. Blight and blossom end rot are the two most important diseases to contend with, and a relatively high percentage of cracking in the Bonny Best variety always occurs. Four distances of planting were involved in rows 15 feet long and 3 feet apart. The plots each year were replicated 4 times in a Latin Square. Within the rows plants were spaced at 12, 18, 24 and 30 inches. The following gives the number of plants grown on each plot, also the number that would be required on an acre basis:

12 inches apart gave	14 plants per plot	=	14520 per acre.
18 inches apart gave	10 plants per plot	=	9680 per acre.
24 inches apart gave	8 plants per plot	=	7260 per acre.
30 inches apart gave	6 plants per plot	=	5800 per acre.

Plants spaced at 12 inches and staked require 14,520 stakes per acre. In order to obviate the use of such large numbers of stakes a system of wiring was used. Four plot rows, end to end, were approximately 66 feet long. A post 4 inches square was firmly imbedded at the end of each row, and at a height of 54 inches from the ground a number 14 gauge wire was tightly stretched between posts. A second wire was put 6 inches above the ground level. At each plant a string was tied to the top and bottom wire and as plants grew they were twisted around the string. To afford additional support a stake 2 inches square was driven in at 15 foot distances along the row to which the top wire was fastened. The bottom wire can be avoided by tying the string to a small peg driven in beside each plant. This method of training closely set plants requires considerably

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less material and less labour than does the method of staking. The greatest saving of time is in tying, and pruning is also made easier. The plants each year were trained to a single stem.

RESULTS

Tables of plot yields are not given, as summaries in this experiment record comparative yields satisfactorily, the results each year between plots having been very uniform. The following tables show the various data obtained.

TABLE 1.—AVERAGE YEARLY YIELD OF TREATMENTS FROM FOUR PLOTS

Year	12-inch	18-inch	24-inch	30-inch
	lb.	lb.	lb.	lb.
1935	57.1	35.6	32.2	24.9
1936	78.7	63.3	61.5	46.2
1937	69.1	60.4	45.6	36.8
1938	58.7	45.1	42.8	30.9

In Table 1 a consistently higher yield is shown for close planting, and the 12-inch distance is recommended. This trend prevailed throughout the experiment in the various plots from year to year.

TABLE 2.—AVERAGE YEARLY YIELD PER PLANT FROM FOUR PLOTS OF EACH TREATMENT—

Year	12-inch	18-inch	24-inch	30-inch
	lb.	lb.	lb.	lb.
1935	4.1	3.5	4.0	4.2
1936	5.6	6.3	7.7	7.7
1937	5.0	5.9	5.7	6.1
1938	4.2	4.6	5.3	5.5

In Table 2 the average figures do not, nor do those of the individual plots, show as marked a trend as the total yield figures per plot and it is therefore assumed that close planting decreases to only a very limited extent the yield of individual plants.

TABLE 3.—AVERAGE NUMBER OF FRUITS PER PLANT FROM FOUR PLOTS OF EACH TREATMENT

Year	12-inch	18-inch	24-inch	30-inch
1937	14.2	17.0	16.1	18.7
1938	14.8	15.0	18.9	15.5

The average figures in Table 3 do not, nor do those of the individual plot yields, show any trend in number of fruits per plant and it is therefore assumed that distance of planting has no effect on this aspect of production.

The figures in Tables 4 and 5 do not, nor do those of the individual plot yields, show any consistent trend as to the percentage of culls or the size of fruit for the different treatments. There is, however, a slight upward trend for size of fruit for more distant spacing. It is therefore assumed that distance of planting has no appreciable effect on these aspects of production.

TABLE 4.—AVERAGE PERCENTAGE OF CULLS FROM FOUR PLOTS OF EACH TREATMENT

Year	12-inch	18-inch	24-inch	30-inch
	%	%	%	%
1937	21.3	20.8	23.9	16.9
1938	26.1	33.6	30.5	33.6

TABLE 5.—AVERAGE SIZE OF FRUIT FROM FOUR PLOTS OF EACH TREATMENT

Year	12-inch	18-inch	24-inch	30-inch
	oz.	oz.	oz.	oz.
1937	5.6	5.7	5.7	5.6
1938	4.5	4.8	4.7	5.1

DISCUSSION AND CONCLUSIONS

Tomatoes for many years in many producing centres in North America have been pruned and tied to stakes. In recent years this method of production has been on the increase. The practice of pruning and staking tomatoes, however, is not universally popular. Huelsen (2) in Illinois states that it is always dangerous to remove any part of the foliage. Allen and Talbot (3) in Missouri found staked plants to yield more than unstaked plants and suggest 2 to 3 feet apart in rows 3 to 4 feet apart. In Ontario, MacLennan and Presant (4) suggest plants 18 inches apart in rows spaced $3\frac{1}{2}$ to 4 feet. Another method practised amongst large growers in Ontario is to plant 2 adjacent rows 2 feet apart with plants 18 inches apart and leave 4-foot spaces between double rows. This is not as close planting as 12 inches apart in rows spaced 3 feet apart. Beattie (5) refers to planting distances in Texas, Mississippi, Florida and New Jersey and in the New England States, where tomatoes are grown under the most intensive pruning and staking methods. The number of plants used in these various states varies from 3000 under Florida conditions to 10,000 under New England States conditions where a double row system is used, pairs of rows being 18 inches apart and plants 18 inches in the row leaving 42 inches between double rows. The approximate distance on this basis is only slightly greater than with plants 12 inches apart in rows 3 feet apart, with the number of plants per acre 14520. The figure of 10,000 plants given by Beattie would indicate that the exact distances under field conditions are not closely followed.

The data submitted in Table 1 show the yield per acre for 12, 18, 24 and 30 inches to be 63,646, 49,368, 44,044 and 33,389 pounds. Under the

conditions of this experiment, failure to plant close to the maximum number of plants would under field conditions represent an appreciable loss of tonnage per acre. Table 2 brings out the fact that close planting decreases the yield from individual plants to a small extent but not enough to offset the advantage of the total plant yield. Tables 3, 4 and 5 do not show a sufficiently marked trend to account for the smaller yield per plant from close planting. In Table 5 the trend would however, indicate a slight increase in size of fruit. It is assumed here that several factors are involved in the decreased yield per plant, each exerting a small influence which did not clearly manifest itself under the conditions of this experiment.

Under a wide variety of soil, moisture and climatic conditions it is to be expected that different or modified results would be obtained. Conditions in 1938 provided an opportunity to make some measurements in respect to variable soil fertility and a decreased supply of moisture. In this year of the experiment one-half of the plots were on considerably more fertile soil than the other, yet the ratio of increase from close to distant planting was the same as with plots on fertile soil. The year 1938 was one of very low rainfall, especially during the season from June to September inclusive. For the years 1935 to 1938 the total rainfall, June to September, was respectively 12.54, 11.16, 10.23 and 3.84 inches. The low precipitation during 1938 gave the same differences in ratio of yield between different distances as were obtained in the 3 previous years. Close planting under the soil conditions of this experiment does not make moisture a limiting factor.

The picking season each year was divided into weekly intervals, and throughout the 4 years of the experiment the largest amount of early ripe fruit was from the 12-inch spacing, the yield of early ripe fruit bearing a definite relationship to the total yields at the end of the season.

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A SCORING SYSTEM FOR CANNING TOMATOES¹

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The grower of canning tomatoes desires a variety that will give maximum yields with a high percentage of No. 1 fruit. The fruits must ripen evenly and be as free as possible from sunscald or green top. They must be free from roughness, ridges, lobing, cracking and splitting. They should preferably be round or oval with a diameter not less than $2\frac{1}{2}$ inches nor more than $2\frac{7}{8}$ inches.

After canning, the product should be bright red in colour and should contain as many whole tomatoes or large pieces as possible. It should have a high percentage of drained solids and should also have a high percentage of soluble solids as shown by a refractometer reading. The fruit should have a good flavour and it should be free from large cores.

To determine the most suitable variety when many strains and varieties are being tested, a scoring system has been devised to show concisely the extent to which each variety meets all the requirements of both the grower and the canner. Fifty per cent of the score is allowed for cultural qualities, that is, requirements of the grower; and fifty per cent is allowed for canning qualities, that is, the requirements of the canner. This scoring system is adapted for experimental hand packing. Deductions for defects might have to be modified for different canning procedure.

CULTURAL SCORE

Yield, percentage of culls, size of tomato, shape, and size of cavity have been allotted points after careful consideration of the relative importance of each in judging the merits of the fruit as it arrives at the cannery.

Yield

In harvesting, all ripe fruit is picked and graded as marketable and unmarketable. The picker carries 2 pails and the product is weighed and totalled at the end of each row at each picking. At the end of the season, the yield of each variety is totalled. Special efforts are made to maintain a full stand of plants in each plot. However, to compensate for the occasional blank due to disease or other mishap, yields are reduced to the basis of a single plant by dividing the total yield by the number of plants harvested. Yields are then arranged in descending order and divided equally into 4 parts. The top quarter is allotted 14 points, the next 10.5, the next 7.0 and the lowest 3.5 points.

Percentage of Culls

The percentage of culls is calculated from the total yield of fruit and the total yield of culls per plant for the season. The resulting figures are arranged in ascending order and divided into 4 equal groups. The lowest quarter is allotted 14 points, the next 10.5, the third 7.0 and the fourth 3.5. If any variety shows an exceptionally high percentage of culls, the score may be cut to zero.

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Size

Fruit calipers graduated in 32nds of an inch are used to measure the polar diameter and the maximum and minimum equatorial diameters of 10 fruits selected at random from each variety. Fruits averaging $2\frac{3}{4}$ to $2\frac{7}{8}$ inches are allotted 10.0 points. Fruits averaging $2\frac{1}{2}$ to $2\frac{3}{4}$ inches and fruits averaging over $2\frac{7}{8}$ inches are each allotted 7.0 points, while very small fruits averaging less than $2\frac{1}{2}$ inches are cut to 3.5 points.

Shape

The relation of polar diameter to equatorial diameter is considered when scoring for shape. Fruits that are round or oval and smooth are allotted 6 points. If decidedly oval and ridged or lobed they are allotted 4.0 points; and if cracks and splits occur they are cut to 2 points. If cracking is very bad or fruits are very rough, the score is cut to zero.

Cavity

If the fruit is smooth with a shallow, narrow cavity showing little loss on peeling, the score is 6 points. A medium wide or deep cavity scores 4 points; and if the cavity is very deep or wide, the score is 2 points.

CANNING SCORE

At least three cans of each variety are canned at harvest time. Later in the season the cans are opened individually and scored for colour, drained weight, total solids by refractometer, and number of whole fruits. During the process of canning, the fruits are scored for flavour, cells, cell walls, and core.

When the cans are being scored the can is first weighed in grams. By counterbalancing an empty can the net weight of can contents is obtained. The contents are then dumped on to a screen, two meshes to the inch, and allowed to drain for one-half minute. From the screen the drained fruit is transferred to granite pans for examination while the juice is measured in graduated cylinders. From its volume the percentage of dry matter is determined. Refractometer readings are made of the juice of each sample immediately after draining.

Colour

Bright red fruits are scored 3, light red 2, the presence of yellow ribs cuts the score to 1, and if a green shoulder occurs that particular fruit is cut to $\frac{1}{2}$ point. The score for the can is calculated on the basis of 4 fruits. The number in each class is multiplied by its score, then these are totalled and reduced to a basis of 4 fruits. For example, if 3 bright red, 1 light red, 1 yellow rib, and 1 green shoulder occur in a can, the score would be 3 times 3 for bright red, plus 1 times 2 for light red, plus 1 times 1 for yellow rib, plus 1 times $\frac{1}{2}$ for green shoulder; making a total of $12\frac{1}{2}$ points. There are 6 fruits in the can so the score of 12.5 must be multiplied by $\frac{4}{6}$, giving a score of 8.33 points for colour.

Drained Weight

After deducting the weight of juice in grams (which for working purposes is equal to the volume in cubic centimetres) from the total weight of the contents of the can, the percentage of remaining solids is calculated and arranged in descending order. The top one-third scores 10 points,

the middle third scores 7, and the lower third scores 3.5 points. If the number is very large, the list may be divided into 4 groups, scoring 10, 8, 6 and 4 points respectively.

Number of Whole Fruits

A No. 2½ can is filled with four tomatoes of average size. In addition, one tomato is broken up to provide liquid to fill the interstices. If the tomatoes are very large, no whole tomatoes may be included but a number of large pieces which give the can a fairly attractive appearance when opened. As the pieces decrease in size, the can loses its attractiveness. A detailed score has been compiled to cover all possible combinations, as follows:

3 or more whole fruits	10 points
2 whole fruits, rest large pieces	8
2 whole fruits, rest small pieces	6
1 whole fruit, rest large pieces	7
1 whole fruit, rest small pieces	5
1 whole fruit, rest of can mush	4
0 whole fruits, all large pieces	7
0 whole, but 4 large pieces	7
0 whole, but 3 large pieces	6
0 whole, but 2 large pieces	5
0 whole, but 1 large piece	4
Whole can mush	0

Total Solids by Refractometer

A total of 7.5 points has been allotted in the score for total soluble solids. In scoring, the actual refractometer reading is taken.

Core

It has been found easier to determine the presence of cores in the fresh fruit than in the canned product. The varieties are scored by cutting 5 fruits. If little or no core is found, the score is 2.5 points; a medium sized core in one or more fruits scores 1.5; and a large core in one or more fruits scores 0.5 points.

Cells and Cell Walls

These are determined when the fruits are cut for core. Small cells or locules score 1.5, medium cells score 1.0, and large cells score 0.5 points. Thick locule or cell walls score 2.5 points, medium walls score 1.5, and thin cell walls 0.5 points.

Flavour

Flavour is largely a matter of personal choice. However it has been allotted 5 points in this scoring system. Full points are allowed unless the flavour is insipid or extremely acid, when the score would be cut 2 to 4 points. Unusual flavours such as are found in some Italian varieties, if considered undesirable, are cut one or more points.

Earliness of Maturity

In the Okanagan Valley it is a common practice for tomato growers to ship semi-ripe fruits from their crop until the plants come into full bearing.

About this time the price for semi-ripe tomatoes drops off rapidly as the market becomes more or less glutted. The canneries begin to operate when this condition occurs. Nearly all varieties are bearing ripe fruits by this time and earliness of maturity is not an important factor from the standpoint of canning tomatoes. Occasionally a very late variety is found which is only coming into full bearing when the cannery season closes or when frosts are likely to occur. The experimental picking closes at a time to coincide with the cannery season, usually the end of September. The reduced yields from these late varieties automatically place them well down in the list. Accordingly, no special provision is made for evaluating season of maturity in this scoring system. However, if it is considered desirable to put a premium on earliness of maturity, an arbitrary date such as Labour Day may be selected. Because of the long week-end, an effort is usually made to complete picking of all plots on the Saturday prior to Labour Day and this makes a suitable date at which the yields may be divided. All yields prior to Labour Day can be totalled and arranged in descending order. They may then be divided into 4 equal groups and scored on the basis of total yield up to that date.

Occasionally a variety may be included in the tests that has an exceptionally high percentage of culls; that is very subject to disease; that is too small for economical handling; or in some other way is undesirable for commercial purposes. In such cases, the variety would be scored in the ordinary way and a warning remark added by a foot-note indicating the undesirable characteristic.

SUMMARY

A scoring system has been devised for comparison of cultural and canning qualities of tomatoes.

The relative importance of different characteristics has been considered in allotment of points.

Detailed methods for scoring have been worked out.

Scores allotted for different characteristics are as follows:

Cultural Characteristics

Yield	14.0	
Percentage of culls	14.0	
Size of fruits	10.0	
Shape (including cracks)	6.0	
Cavity	6.0	
Total		50

Canning Characteristics

Colour	12.0	
Drained weight	10.0	
Number of whole fruits	10.0	
Total solids by refractometer	7.5	
Core	2.5	
Cell size	1.5	
Cell walls	1.5	
Flavour	5.0	
Total		50

CHEMICAL CONSTITUENTS OF SOME FRUITS GROWN IN BRITISH COLUMBIA¹

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INTRODUCTION

Information concerning the chemical constituents of fruits is useful in determination of such factors as maturity, suitability for processing, and purity of manufactured products. For instance, the maturity of cherries is closely correlated with sugar content; the suitability of prunes for dehydration depends largely on the percentages of sugar and acid they contain; and the insoluble solid content of berries is of value in ascertaining the purity of products made therefrom.

With these facts in mind, analysis of fruits grown commercially in British Columbia was begun in 1931. Additional data have been secured each year and the work is still in progress.

MATERIALS AND METHODS

Analyses have been made of the following varieties:

Apples: Delicious, Grimes Golden, Jonathan, McIntosh, Newtown, Ontario, Rome Beauty, Northern Spy, Stayman, Wagener, and Winesap.

Apricots: Blenheim, Royal.

Peaches: Valiant, Vedette, Veteran, No. 4108, J. H. Hale, and Elberta.

Cherries: Royal Ann, Bing, Lambert, Deacon.

Prunes: Italian.

Grapes: Angevine, Agawam, Burgunder, Blau Frankisch, Campbell Early, Chasselas Rouge, Concord, Delaware, Fredonia, Muscat Ferdinand de Lessups, Muscat Ottonel, Moore's Early, Niagara, Ontario, Oberlin 595, Patricia, Pearl of Csaba, Portland, Rauschling, Riesling-Sylvaner, Seibel 2838, Seibel 5279, Seibel 5455, Seneca, Sheridan, Worden.

Currants: Boskoop Giant, Climax, White Grape, Perfection.

Strawberries: Royal Sovereign, British Sovereign, Beauty, Fairfax, Laxton, Red Heart.

Raspberries: Cuthbert, Latham, Lloyd George, Newburg, Taylor, Viking.

Most of the fruit analyzed was grown on the Summerland Experimental Station. However, samples of Delicious apple were secured from Salmon Arm, Vernon, Winfield, and Oyama. Samples of British Sovereign strawberry were secured from Victoria, Kelowna and Nelson; Royal Sovereign from Kelowna; Beauty and Fairfax from Nelson; Laxton and Red Heart from Victoria. Cuthbert, Lloyd George, and Viking raspberry were secured from Kelowna as well as from the Experimental Station plantation.

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In many cases analyses were made of fruit of the same variety grown in different seasons. For instance, with the Delicious apple, fruit was secured from two trees in each of the Salmon Arm, Vernon, Oyama, and Winfield districts in 1931, and from the same trees in 1932. Furthermore, the fruit from each of these trees was graded for red colour into Extra Fancy, Fancy and Cee, each grade being analyzed separately.

With all fruits, material for analysis was taken from sufficiently large lots to ensure representative samples. For example, in comparing varieties of apples, samples were taken from 40-gallon barrels of juice pressed from "orchard run" fruit.

With apples and grapes, the fresh expressed juice was used in the analyses. With the other fruits, analyses were made on the pulped fruit. With few exceptions, analyses were made when the fruit was at the eating-ripe stage of maturity.

Data were secured concerning the following constituents: solids: total, water insoluble, and soluble; sugars: total, reducing, and sucrose as invert; acid; tannin; pectin; ash; and pH.

These constituents were determined according to the methods of the Association of Official Agricultural Chemists. The Lane and Eynon method was used in the estimation of sugars. Soluble solids were estimated by use of a Zeiss refractometer graduated to read in percentage sugar by weight at 20° C.

RESULTS

The results of the analyses are expressed in percentage by weight of the fresh fruit or juice analyzed, the data secured being embodied in the tables which form an appendix to this paper. The results may be briefly summarized as follows:

Apples

In juice from apples the percentage of total sugar ranged from 10.7 to 14.7, acid from 0.25 to 0.57, and tannin from 0.02 to 0.05.

Delicious, Grimes Golden and McIntosh were lower in acid and tannin than Jonathan, Ontario, Stayman and Winesap.

Delicious, Jonathan, Stayman and Winesap had comparatively high average sugar content, but there were marked differences in the sugar content of the same variety in different seasons. For instance, in comparable samples of Delicious picked from the same trees in two different years, there were differences in sugar content of over 3%. Similarly, there were differences of over 3% in total sugar content of Delicious apples secured from different districts in the same season. Furthermore, in Delicious apples picked from the same tree on the same day, there was about 1% more sugar in Extra Fancy than in Cee grade fruit.

Apricots

In Blenheim and Royal apricots analyzed at shipping maturity, total sugar averaged about 9%, and acid 1.6%, whereas in eating-ripe fruit sugar averaged over 11 and acid about 1%.

Peaches

In peaches, sugar content ranged between 7 and 11%, and acid between 0.5 and 0.8%.

Cherries

Royal Ann, Bing, Lambert and Deacon cherries of satisfactory maturity for glacing had a soluble solid content of about 14.5, 14.5, 15 and 12% respectively.

Royal Ann, Bing, Lambert and Deacon cherries of too advanced maturity for glacing had soluble solid contents as high as 20, 24, 20 and 18% respectively.

Fruits of Royal Ann with a fairly high soluble solid content produced a glazed product of satisfactory colour but were inclined to split in the brine solution.

Fruits of the dark varieties gave a glazed product of undesirable dark colour when picking was delayed until they had passed the "tomato red" colour.

Prunes

The percentage of Italian prunes developing insufficient sugar to make a good dehydrated product varied from 26 to 57% of the total crop in different seasons.

Flotation in brines of different strength proved an effective means of separating large quantities of prunes of different sugar content.

Prunes left on the tree to ripen showed a progressive decrease in acid for several weeks after they had attained maximum sugar content.

Grapes

Total sugar content of the 26 varieties of grapes tested ranged from 12 to 25%, acid from 0.38 to 2.25%, and tannin from 0.006 to 0.208%.

Grapes of the following varieties were found to produce medium sweet wines of good quality: Burgunder, Campbell Early, Muscat Ferdinand de Lessups, Muscat Ottonel, Portland, Rauschling, Riesling-Sylvaner, Seibel 2838, and Seibel 5279.

Currants

With black, white, and red currants, total sugar content ranged between 5.3 and 6%; acid content between 1.5 and 2%; and pectin between 0.6 and 1.7%; red currants being highest in acid and black currants notably high in pectin.

Strawberries

In five varieties of strawberries the percentage of insoluble solids ranged between 2 and 4%, total sugar between 5.5 and 8.5%, acid between 0.66 and 1.47%, and pectin between 0.45 and 0.85%.

The insoluble solid content of British Sovereign strawberries secured from three districts the same season was 2.3, 3 and 4% respectively.

Raspberries

In six varieties of raspberries analyzed, the percentage of insoluble solids ranged between 4.5 and 6.4%; soluble solids between 9.4 and 14.2%; acid between 1.2 and 2.1%; and pectin between 0.53 and 0.70%.

The total solid content of Lloyd George raspberries picked from the same patch was 16% one year and 13% another.

DISCUSSION

The variation in composition of fruits of different varieties, and in the composition of the same variety from different districts and in different seasons, which is revealed in Appendix Tables 1 to 11, is of importance to the processing industry. For instance in canning, preserving and juice manufacture, variations in sugar content of the fresh product should be adjusted by varying the amount of sucrose or other sugar added. In the making of wine, variations in the sugar, acid and tannin content of the grapes should be taken into account in blending. Similary in the making of fruit juices, cider and vinegar, the process should be modified in accordance with the analysis of the fresh juice.

With cherries, soluble solid content can be used as a means of determining the suitability of the fruit for glacing, and with prunes, grading in accordance with sugar content is essential in order to secure a product of uniform quality.

APPENDIX

TABLE 1.—ANALYSES OF APPLE JUICE FROM DIFFERENT VARIETIES

Variety	Year	Specific gravity	Acid as malic	Sugar as invert			Tannin
				Total	Reducing	Sucrose	
			%	%	%	%	%
Delicious	1933	1.052	0.28	12.45			0.023
	1936		.23	14.03	10.04	3.99	.023
Grimes Golden	1933	1.046	.29	10.75			.025
Jonathan	1933	1.060	.53	13.75			.030
	1936		.57	12.75	10.05	2.70	.030
McIntosh	1933	1.047	.30	10.79			.021
	1936		.37	12.97	11.69	1.28	.021
Newtown	1933	1.053	.45	12.08			.031
	1936		.53	12.45	10.14	2.31	.023
Ontario	1933	1.050	.56	11.15			.027
Rome Beauty	1933	1.054	.39	12.48			.034
Spy	1933	1.052	.43	11.94			.035
Staymen	1933	1.064	.42	14.74			.052
Wagener	1933	1.052	.37	12.19			.027
Winesap	1933	1.058	.48	13.23			.042

TABLE 2.—ANALYSES OF DELICIOUS APPLE JUICE FROM DIFFERENT DISTRICTS AND DIFFERENT SEASONS

District and strain	Year	Dry* matter	Acid as malic	Sugar as invert			pH
				Total	Reducing	Sucrose	
		%	%	%	%	%	
Salmon Arm (Turner)	1931	17.2	0.22	13.18	9.67	3.45	4.06
	1932	15.9	.14	14.37	12.11	2.26	
	Max.	18.0	.24	14.82	12.39	3.75	
	Min.	15.4	.11	12.52	9.21	1.91	
Vernon (Goodenough)	1931	15.5	.24	12.31	10.30	2.01	3.90
	1932	14.7	.16	13.10	10.07	3.03	
	Max.	16.0	.27	13.40	10.32	3.26	
	Min.	14.4	.14	11.55	9.25	1.05	
Oyama (Towgood)	1931	17.0	.25	13.61	10.06	3.52	4.10
	1932	13.0	.13	12.01	9.06	2.95	
	Max.	17.5	.26	13.66	10.69	4.06	
	Min.	12.6	.11	11.75	8.82	2.79	
Winfield (Coe)	1931	18.2	.23	14.70	10.57	4.13	4.20
	1932	12.6	.14	11.03	9.78	1.24	
	Max.	18.5	.23	14.71	11.37	4.94	
	Min.	12.0	.13	10.55	9.67	0.88	

* Determined on the fresh pulped fruit.

TABLE 3.—RELATION OF SKIN COLOUR AND SUGAR CONTENT OF DELICIOUS APPLES

Skin colour grade	Reducing sugar	Sucrose as invert	Total sugar
	%	%	%
Extra fancy	12.39	2.43	14.82
Fancy	12.00	2.38	14.38
Cee	12.00	1.91	13.91

TABLE 4.—ANALYSES OF APRICOTS AND PEACHES

Fruit	Year	Insoluble solids	Soluble solids	Sugar as invert			Acid as malic	Ash	Pectin	pH
				Total	Reducing	Sucrose				
		%	%	%	%	%	%	%	%	
<i>Apricots</i>										
Blenheim (Summerland)	1932			9.87			0.85			
Blenheim	1937	1.48	15.3	11.30			1.04	.74	.77	
Royal (Summerland)	1937	1.31	16.1	11.74			1.11	.69	.73	
Average of 16 lots*	1934		12.0	9.07	7.98	1.85	1.60			3.68
<i>Peaches</i>										
Valiant (Summerland)	1932			7.13			.57			
Vedette (Summerland)	1932			8.16			.69			
Veteran (Summerland)	1932			10.35			.54			
4108 (Summerland)	1932			10.49			.49			
*J. H. Hale (Summerland)	1934		11.1				.73			
*Elberta (Summerland)	1934		10.9				.75			
*Average of 50 lots	1934		10.7	8.92	2.79	6.09	.68			

* Analyzed at shipping maturity.

TABLE 5.—RELATION OF MATURITY OF CHERRIES TO SUITABILITY FOR PROCESSING

Variety	Soluble solids at processing maturity	Colour of bleached product	Soluble solids of over-mature fruit for processing	Colour of bleached over-mature fruit
Royal Ann	14.5	Straw yellow	20.2	Straw yellow
Bing	14.6	Straw yellow	23.8	Strong pink
Lambert	15.3	Straw yellow	20.2	Strong pink
Deacon	11.8	Straw yellow	18.3	Strong pink

TABLE 6.—COMPARISON OF SUGAR CONTENT OF ITALIAN PRUNES AT FULL MATURITY IN YEARS 1935 AND 1936

	Prunes floating in 20° S. brine		Prunes floating in 35° S. brine		Prunes sinking in 35° S. brine	
	1935	1936	1935	1936	1935	1936
Percentage of crop	56.9	26.27	25.4	16.5	17.7	57.23
Total solids by refractometer	10.6	14.10	18.3	21.3	23.2	27.48

TABLE 7.—RELATION OF BRINE SEPARATION GRADES TO SUGAR AND ACID CONTENT OF ITALIAN PRUNES

Strength of brine	Soluble solids	Acid as malic
°S.	%	%
15° Floaters	12.07	1.11
20° Floaters	14.70	0.94
25° Floaters	16.82	0.94
35° Floaters	17.52	0.94
35° Sinkers	21.04	0.94

TABLE 8.—COURSE OF RIPENING OF ITALIAN PRUNES INTENDED FOR DEHYDRATION

Date harvested	Soluble solids	Total acid as malic	pH
	%	%	
Sept. 13	18.8	1.17	3.39
Sept. 21	21.0	1.02	3.50
Sept. 26	22.0	0.94	3.52
Oct. 1	21.3	0.90	3.60
Oct. 4	22.2	—	—

TABLE 9.—ANALYSES OF GRAPE JUICE

Variety	Year	Soluble solids	Sugar as invert			Acid as tartaric	Tannin	Ash	pH
			Total	Reducing	Sucrose				
		%	%	%	%	%	%	%	
Angevine	1935	16.8				.61	.021		
Agawam	1937	19.1	16.87	16.77	.10	1.32	.035		
*Burgunder	1936	16.5	15.48	15.48	0.00	.79	.012		
Burgunder	1937	16.5	15.35	15.17	.18	.73	.011		3.02
Burgunder	1938	12.6	11.55	11.29	.26	.51			
Blau Frankisch	1938	18.8	17.22	17.05	.17	.74	.027	.22	3.38
*Campbell Early	1935	15.5				.69	.041		
Campbell Early	1937	15.0	13.16	13.16	0.00	1.15	.073		3.28
Campbell Early	1938	17.7	16.03	15.50	.53	.60			
Chasselas Rough	1937	13.4	12.05	12.05	0.00	.97	.012		
Concord	1937	15.9	14.38	14.20	.18	.98	.035		3.01
Delaware	1937	17.8	16.32	16.25	.07	.83	.019		
Fredonia	1935	15.7				.52	.052		
Fredonia	1937	15.0	12.48	11.90	.58	1.26	.143		3.16
*Muscat Ferdinand de Lessups	1937	15.8	14.34	14.34	0.00	.96	.022		3.10
Muscat Ferdinand de Lessups	1938	14.2	13.10	13.05	.05	.57	.022		3.28
*Muscat Ottonel	1938	16.4	15.28	15.28	0.00	.44	.021	.19	3.50
Moore's Early	1935	18.3				.49	.031		
Niagara	1937	14.6	13.03	12.36	.67	.73	.032		
Ontario	1935	17.8				.60	.045		
Oberlin 595	1935	23.8				2.25			
Oberlin 595	1936	27.4	24.22	24.22	0.00	1.75	.172		
Oberlin 595	1937	20.4	17.84	17.84	0.00	1.68	.085		3.13
Oberlin 595	1938	28.2	25.34	25.34	0.00	1.83	.208	.47	3.28
Patricia	1935	13.7				.50	.052		
Pearl of Csaba	1938	19.0	17.72	17.57	.15	.57	.020		3.50
*Portland	1935	15.8				.43	.024		
Portland	1937	14.1	12.75	10.01	2.74	.83	.019		3.10
Portland	1938	18.0	16.73	12.02	4.74	.38	.046	.27	3.76
*Rauschling	1936	17.3	16.22	16.22	0.00	.73	.012		
Rauschling	1937	14.3	13.23	13.23	0.00	.64	.015		3.28
Rauschling	1938	13.7	12.43	12.36	.07	.62			
*Riesling-Sylvaner	1937	16.4	15.12	15.12	0.00	.83	.006		3.08
Riesling-Sylvaner	1938	18.1	16.63	16.27	.36	.72			
*Seibel 2838	1935	15.8				.63	.041		
Seibel 2838	1937	13.5	12.08	12.08	0.00	.64	.021		
Seibel 2838	1938	16.3	15.52	15.30	.22	.50	.023		3.42
*Seibel 5279	1936	19.0	17.57	17.57	0.00	1.01	.030		
Seibel 5279	1938	18.9	17.18	17.11	.08	.86	.024	.26	3.30
Seibel 5455	1936	18.7	16.85	16.85	0.00	1.50	.046		
Seibel 5455	1937	14.7	12.71	12.71	0.00	1.54	.026		2.85
Seibel 5455	1938	18.2	16.27	16.22	.05	1.27	.012	.26	3.09
Seneca	1935	19.5				.72	.041		
Sheridan	1937	15.3	13.54	9.50	4.04	1.08	.039		3.00
Worden	1937	14.7	12.08	11.04	1.04	1.49	.097		3.16

* Varieties which have been found to give medium sweet wines of desirable quality.

TABLE 10.—ANALYSES OF CURRANTS—1938

Variety	Source	Total solids	Insoluble solids	Soluble solids	Sugar as invert			Acid* as citric	Ash	Pectin	pH
					Total	Reducing	Sucrose				
		%	%	%	%	%	%	%	%	%	
<i>Black Currants</i>											
Boskoop Giant	Grand Forks	20.06	7.73	11.9	5.47	5.47	0.00	1.51	.99	1.67	2.98
Climax	Summerland	21.9	7.33	15.0		7.49		1.81	1.04	1.61	2.83
<i>White Currant</i>	Summerland	13.99	5.47	9.6	5.32	4.98	0.34	1.85	.67	.62	3.02
<i>Red Currant</i>	Summerland	14.05	5.98	9.0	6.05	5.78	0.27	2.04	.69	.60	3.20

* Anhydrous.

TABLE 11.—ANALYSES OF STRAWBERRIES AND RASPBERRIES

Variety	Source	Year	Total solids	Insoluble solids	Soluble solids. †	Total sugar as invert	Acid as citric*	Ash	Pectin	pH
			%	%	%	%	%	%	%	
<i>Strawberries</i>										
Royal Sovereign	Kelowna	1934	16.34	2.87	14.07		1.55	.67		
British Sovereign	Victoria	1937		2.26	11.5	8.51	.94			.66
British Sovereign	Kelowna	1937		3.07	10.1	6.10	1.36			.69
British Sovereign	Nelson	1937		4.01	10.6	6.48	1.47	.61		.74
Beauty	Nelson	1937		3.38	8.9	5.87	1.10	.51		.65
Fairfax	Nelson	1937		2.55	10.4	6.27	1.27	.72		.72
Laxton	Victoria	1937		2.01	7.4	5.51	.66			.45
Red Heart	Victoria	1937		2.50	10.5	7.11	1.03			.85
<i>Raspberries</i>										
Cuthbert	Summerland	1934	19.52	6.37	14.16		1.21	.55		
Cuthbert	Kelowna	1937		5.97	9.4	5.62	1.37	.45		.55
Latham	Summerland	1934	15.64	4.87	11.07		1.56	.47		
Lloyd George	Summerland	1934	16.15	4.50	12.70		2.10	.57		
Lloyd George	Summerland	1938	13.02	5.21	9.6	4.74	1.98	.63	.65	3.25
Newburg	Summerland	1938	13.93	5.78	9.5	5.10	1.65	.56	.70	3.18
Taylor	Summerland	1938	14.05	6.31	9.5	4.95	1.91		.68	3.10
Lloyd George	Kelowna	1937		5.79	9.9	6.66	1.28	.42	.53	
Viking	Kelowna	1937		5.37	10.4	7.07	1.29	.43	.56	

† Determined on juice of ground sample.

* Anhydrous.

GREENHOUSE FERTILIZER STUDIES OF CELERY¹

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Greenhouse investigations of the food requirements of crop plants often lead to valuable conclusions as to what elements are required for optimum growth, and in what quantities. A greenhouse is the ideal place in which to carry on such experiments, since all factors are under control and may be varied at will. Furthermore, crops may be grown under glass at all seasons and much valuable time may be saved. It is realized, however, that methods which may give ideal results under glass may not give equivalent reactions when the crop is grown on a commercial basis out of doors.

Soils vary a great deal in their texture, fertility, water-holding capacity, and ability to retain nutrient elements without leaching. Due to these properties of the soil, fertilizer experiments in the field give results which are applicable only to the plots on which the experiments were conducted, or at best, to the closely adjoining portions of land. They yield practically no information as to what is required by the individual crops for their optimum growth. The best way at the present time to show which elements are of most value to the plant is by the use of water and sand cultures.

In these investigations with celery as the crop plant, the sand culture method was used. Pure quartz sand was employed and nutrient solutions were applied each week. For comparison, plants were also grown on muck and on mineral soils to which commercial fertilizers were added. The nutrient solutions used in the sand culture experiment contained the same amounts of nitrogen, phosphorus and potash as did the commercial fertilizers applied to the soils. Very interesting results were obtained from this experiment, which involved the three soil types.

MATERIALS AND METHODS

Twenty-seven fertilizer mixtures were employed in this work. These treatments consisted of 3 levels each of nitrogen, phosphorus and potash. Table 1 gives an elaboration of the symbols employed, the fertilizer analyses and the amounts of nitrogen, phosphorus, and potash in pounds per acre. Symbols will be used throughout for the sake of convenience.

Wooden boxes were built into the greenhouse bench in order to separate the treatments from each other. The boxes were made a tight fit to prevent, as much as possible, leaching from one box to the other. The boxes were 2 feet long, 1 foot wide, 8 inches deep for the sand, and 12 inches deep for the muck and mineral soils. The boxes, which had no bottoms, were set on cinders to facilitate drainage.

For the purpose of differentiating between the soil types, the investigation was divided into 3 parts, as follows: Quartz sand, Experiment 1; Muck soil, Experiment 2; Mineral soil, Experiment 3.

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TABLE 1.—FERTILIZER TREATMENTS SHOWING FORMULAE AND ACTIVE INGREDIENTS IN POUNDS PER ACRE

Treatment	Formula	Pounds of N	Pounds of P ₂ O ₅	Pounds of K ₂ O
0-0-0	0-0-0	0	0	0
0-0-1	0-0-16	0	0	320
0-0-2	0-0-32	0	0	640
0-1-0	0-8-0	0	160	0
0-1-1	0-8-16	0	160	320
0-1-2	0-8-32	0	160	640
0-2-0	0-16-0	0	320	0
0-2-1	0-16-16	0	320	320
0-2-2	0-16-32	0	320	640
1-0-0	4-0-0	80	0	0
1-0-1	4-0-16	80	0	320
1-0-2	4-0-32	80	0	640
1-1-0	4-8-0	80	160	0
1-1-1	4-8-16	80	160	320
1-1-2	4-8-32	80	160	640
1-2-0	4-16-0	80	320	0
1-2-1	4-16-16	80	320	320
1-2-2	4-16-32	80	320	640
2-0-0	8-0-0	160	0	0
2-0-1	8-0-16	160	0	320
2-0-2	8-0-32	160	0	640
2-1-0	8-8-0	160	160	0
2-1-1	8-8-16	160	160	320
2-1-2	8-8-32	160	160	640
2-2-0	8-16-0	160	320	0
2-2-1	8-16-16	160	320	320
2-2-2	8-16-32	160	320	640

Experiment 1

The sand used in these experiments was pulverized quartz rock. The celery seeds were germinated in greenhouse soil and when the first true leaves had formed, the seedlings were transplanted into flats containing the quartz sand. They were fed each week with a general nutrient solution until they were about two inches high. The solution used is given in Table 2.

TABLE 2.—GENERAL NUTRIENT SOLUTION FOR SMALL SEEDLINGS

Calcium nitrate, CaNO ₃	102.30 gm.
Magnesium sulphate, MgSO ₄ , 7H ₂ O	40.70 gm.
Superphosphate (16%)	63.34 gm.
Muriate of potash	15.97 gm.
Boric acid, H ₃ BO ₃	0.257 gm.
Manganese sulphate, MnSO ₄ , 4H ₂ O	0.037 gm.
Water	40.00 gallons

When the plants were about two inches tall, they were transplanted into the quartz sand boxes—three plants to each box. This was done on May 27, 1938, and the first feeding of the specially prepared nutrient solutions was made on the following day.

The solutions were made up in such a way that after 13 weeks' growth, the plants in each treatment would have received in total nutrients an amount equivalent to that shown in Table 1.

Table 3 shows the amount of the elements in parts per million which was applied weekly to plants in the 1-1-1 (4-8-16) treatment for the first 4 weeks.

TABLE 3.—PARTS PER MILLION OF ELEMENTS IN SOLUTION FOR THE 1-1-1 TREATMENT FOR THE FIRST FOUR WEEKS

N	44.5	Ca	400.0	Zn	0.1
P	39.0	S	203.0	Fe	8.3
K	142.5	Cl	706.0	Cu	0.1
Mg	96.4	Mn	0.2	B	1.5

Table 4 represents the solution which was applied as the 1-1-1 treatment during the first 4 weeks. Solutions for the other treatments were made up by varying the amounts of nitrogen, phosphorus and potash.

TABLE 4.—CONCENTRATION OF STOCK SOLUTIONS AND THE AMOUNT OF EACH USED IN MAKING UP THE 1-1-1 TREATMENT

Chemical	Grams per litre	Amount of stock solution in 5000 cc. distilled water
NH ₄ NO ₃	90.0	7.06 ccs.
KH ₂ PO ₄	35.0	24.44 ccs.
K ₂ SO ₄	50.0	41.46 ccs.
MgSO ₄ , 7H ₂ O	70.0	69.75 ccs.
CaCl ₂	75.0	73.80 ccs.
MnSO ₄ , 2H ₂ O	0.62	5.50 ccs.
CuSO ₄ , 5H ₂ O	0.333	3.77 ccs.
ZnSO ₄	0.25	4.97 ccs.
FeCl ₃ , 6H ₂ O	5.0	24.20 ccs.
H ₃ BO ₃	1.0	42.88 ccs.

In the case of the no-potash treatments, orthophosphoric acid was used as a source of phosphorus. This solution was made up by diluting 10 cc. of the acid to 1000 cc. and applying 39.3 cc. of the stock solution for the single application.

In the case of 0-2-1, 1-2-1 and 2-2-1, increasing the level of phosphorus to 2 would have supplied too much potash from the potassium phosphate. To overcome this difficulty, a single level of phosphorus was supplied as KH₂PO₄ and the remainder as H₃PO₄. In the treatments receiving no K₂SO₄, the sulphur content was necessarily lowered. This was brought up to normal by adding sufficient sodium sulphate. In the case of the double application of K, the sulphur content was slightly higher than in the rest of the treatments. This was the only element which fluctuated, apart from N, P, and K. However, this fluctuation was relatively unimportant.

At the end of the first 4 weeks' growth, the concentration of nitrogen, phosphorus and potash was increased by 2.45 times the original and so maintained for the remaining 9 weeks. The concentration of the minor elements was not varied throughout the growing season. Distilled water was applied each day to provide sufficient moisture for the plants.

The pH of the solutions was adjusted to 5.5 by adding the appropriate amount of N/10 NaOH to each solution. These solutions were applied each week to the plants at the rate of 600 cc. per plant.

Measurements of height were made on July 5, July 19, and August 1. The length and weight of the roots were determined at harvest on August 1, after the roots had been carefully washed out of the sand.

Experiment 2

The muck soil used in this experiment was brought from Ste. Clothilde de Chateauguay. This soil may be classified as fairly well decomposed muck. McKibbin and Stobbe (8) state: "This soil is equal or superior to the soil of any other area examined in this province." The fertilizer mixtures shown in Table 1 were applied at the appropriate rates and worked into the upper 2 inches of soil. The beds were then saturated with water several times and allowed to stand for a week before the plants were set in them. Three plants were set in each box on November 30, 1938. The plants were watered with tap water when necessary.

Measurements were made on the height of the plants on February 9 and 22, and on March 8 and 22.

Experiment 3

The same procedure was followed as in Experiment 2, except that instead of muck soil, mineral soil was placed in the boxes. This soil was a good quality greenhouse compost made up of garden loam and well decayed manure.

Since there was a temperature gradient towards one end of the house, the muck and mineral soil plots were randomized, as were the treatments on the two soil types.

REVIEW OF LITERATURE

Blake, Nightingale and Davidson (1) found that apple trees which were fed a nutrient solution lacking potassium but otherwise complete, developed as rapidly during the first 2 months of the experiment as did those trees which were fed with a nutrient solution lacking phosphorus or magnesium. Later these trees which were grown under potash deficient conditions began to be superior to those grown under phosphorus and magnesium deficient conditions. None of the trees grown under deficient conditions produced as rapid or as vigorous a growth as did those grown with a complete nutrient solution.

Davis, Hill and Johnson (3) grew strawberry plants under normal conditions for one season and then subjected them to low potassium conditions. These plants were able to cope with the situation to an almost efficient degree, but such was not the case with regard to phosphorus or magnesium.

Gregory (5) found that the effect of deficiency in reducing both the tiller number and leaf area of barley occurred in the decreasing order of N, P, K. Decrease in potassium in all series studied led to an increase in sodium uptake.

Comin (2) considered potash to be of most value on muck soil.

The Sections of Horticulture, Soils, Botany and Entomology of the Michigan Station (11) recommend the use of a commercial fertilizer mixture

containing some phosphate, but high in potash to produce a better yield and better quality of celery than can be obtained by the use of manure alone. The proper ratio of phosphate to potash in the mixture depends chiefly on the time of producing the crop and on the reaction of the soil. They state that an excess of phosphate is likely to produce an undersized crop.

Hoare (6) states that nitrogen and phosphorus are regarded as being more important for celery than potash.

EXPERIMENTAL RESULTS

Experiment 1

Influence of treatments on growth

(a) Height

Since space does not permit, the results of all the measurements will not be tabulated; only figures representing the measurements at harvest will be given prominence, and comments will be made on the measurements at other dates only if they deviate in characteristics from those shown. It should be mentioned that the figures which appear in the tables relative to the effects of the elements on growth are not actual measurements but rather values used in the statistical analysis. Fisher's analysis of variance (4) was used and the significance tested by the *z* value.

TABLE 5.—EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON THE GROWTH IN HEIGHT OF PLANTS GROWN IN SAND CULTURE

0% N	169.6	0% P	198.6	0% K	249.9
4% N	545.6	8% P	576.9	16% K	493.2
8% N	569.8	16% P	509.5	32% K	541.9

Throughout the whole growing season, nitrogen and phosphorus proved to be extremely necessary for the growth in height of the plants. The importance of potash was not evident until about the middle of July, since previous to this date, the plants did almost as well without potash as with it. From the middle of July until harvest, the plants which received no potash in the nutrient solution rapidly deteriorated, the leaves turning yellow and the petioles and leaves drooping.

In Table 5 the difference required for significance is 124.1. Therefore it can be seen that the 4-8-16 fertilizer gave the most significant, though not the maximum response. The response was not as great between the 0 and 16% potash treatments as between the 0 and 4% nitrogen or the 0 and 8% phosphorus treatments.

(b) Weight

TABLE 6.—EFFECTS OF NITROGEN, PHOSPHORUS AND POTASH ON THE WEIGHT AT HARVEST OF TOPS OF PLANTS GROWN IN SAND CULTURE

0% N	8.0	0% P	13.1	0% K	42.8
4% N	411.1	8% P	519.7	16% K	347.2
8% N	569.2	16% P	455.5	32% K	598.2

In Table 6 the difference required for significance is 314.3. The presence *versus* absence of nitrogen, phosphorus and potash is highly significant. It is interesting to note that 0% potash gave somewhat better results than 0% nitrogen and 0% phosphorus, but 16% potash did not result in an increase of significant proportion. A quantity of potash greater than 16% was necessary to bring about a significant difference over and above the zero level as shown by the results of the 32% potash application. The combination of 4% nitrogen, 8% phosphorus and 32% potash brought about the greatest significant weight. The double application of phosphorus had a slightly depressing effect on the weight of the plants.

Since 16% of potash was required to give the greatest significant height and 32% for the greatest significant weight, it appears that potash is required in large amounts to give body to the plants.

A count made on July 5 of all leaves which stood more than one inch above the surface of the sand revealed that 4% nitrogen and 8% phosphorus resulted in an increased number of leaves when compared with the zero treatments. The double applications of these elements had a very slightly depressing effect. There was no significant difference between presence and absence of potash on the leaf count at this date.

Ratios and Correlations

The ratio of length of top to length of root varied with the different treatments. In most cases the ratio was greater than unity only when the 3 elements were present.

The ratio of weight of top to weight of root varied considerably more than the length ratio. This is due presumably to the fact that the roots were air-dried overnight at room temperature before being weighed. Since some of the root systems were much larger and more bushy than others, they retained more moisture, which influenced the results. However, even here the ratios were larger when all 3 of the elements were present in the treatment.

The correlation of length of top to length of root was highly significant with a coefficient of 0.9180. The correlation of weight of top to weight of root was just as significant with a coefficient of 0.9116.

Thus, for each small change in the size of root, there is a corresponding change in the size of top. This is of great importance inasmuch that any factor which affects the root adversely results in a much decreased growth of plant.

Condition of roots

The lack of nitrogen, phosphorus and potash tended to produce small, brownish root systems. When all 3 elements were present, the root systems were large, succulent and white.

The analysis for length of root showed that potash did not affect the length, but on the other hand an analysis for weight showed that a heavy application of potash was necessary before the weight was significantly increased. A further examination of the root system showed something of considerable interest. The length and weight of the roots may not have been unduly affected by potash, but potash had a decided effect on texture.

Figure 1 shows the difference between the 1-1-0 and the 1-1-1 root systems. This shows clearly that the root system lacking potash consisted of long, stringy, coarse roots with very few short, stubby rootlets, and the 1-1-1 root system, which was fed potash, consisted of many fine rootlets which penetrated throughout the soil in all directions supplying the plant with an abundance of water and soil nutrients.

Deficiency symptoms

(a) Nitrogen

In the series lacking nitrogen but receiving both phosphorus and potash, the plants were small, pale green to yellowish white, and of no value. This was on July 16.

(b) Phosphorus

Plants in the series lacking phosphorus were small and of a pale green colour. Many of the leaves had a mottling of bronze.

(c) Potash

The plants in the series lacking potash grew normally until about the fifth of July before the deficiency became noticeable. This deficiency was characterized by pale yellow to green leaves and weak stems which were unable to support the leaves, which consequently had a droopy appearance. Plants in treatments high in nitrogen but lacking potash seemed to be the first to show the deficiency symptoms. The plants very quickly deteriorated once the potash reserve, which they had built up while being fed the general nutrient solution during the seedling stage, was used up.

Condition of plants

The plants in the following treatments at time of harvest were small and of no value:

0-0-0	0-2-0	1-2-0
0-0-1	0-2-1	2-0-0
0-0-2	0-2-2	2-0-1
0-1-0	1-0-0	2-0-2
0-1-1	1-0-1	2-1-0
0-1-2	1-0-2	2-2-0

It is interesting to note that in the above treatments there are no more than 2 elements in any one. It seems that a balance is required before normal growth can take place. An excess of one element does not seem to make up for a deficiency of another.

The plants in the following treatments had good vigorous growth at the time of harvest:

1-1-0	1-2-1	2-1-2
1-1-1	1-2-2	2-2-1
1-1-2	2-1-1	2-2-2

The plants in the 1-1-0 treatment were lacking in potash, but seemed to be able to keep up with the amounts of nitrogen and phosphorus present. Possibly when 2 elements are properly balanced, the deficiency of the third is not quite so noticeable. However, when the root system for the 1-1-0

treatment is examined (Figure 1), it is difficult to understand how such a badly developed root system could support a vigorous plant.

Maximov (7) cites Mitscherlich as suggesting that the increase in one of the nutrient elements slightly augments the effects of the other nutrient substances. Thus, in the case of nitrate deficiency, a potash fertilizer may increase the yield, though according to the law of the minimum, this should not be the case.

Since the potassium can be replaced by sodium to some extent, the explanation for the continued growth of the plants in the 1-1-0 treatment might be found. In making up the nutrient solutions, the sulphur content was maintained in the absence of potassium sulphate by adding an appropriate amount of sodium sulphate. The sodium added here may have been enough, along with nitrogen and phosphorus, to give good growth.

Experiment 2

Effect of treatments on plants

The treatments used on the mineral and muck soils were the same as those used in the sand cultures except that on the 2 soils commercial fertilizers were applied instead of nutrient solutions.

TABLE 7.—EFFECT OF NITROGEN, PHOSPHORUS AND POTASH AT HARVEST ON THE HEIGHT OF PLANTS GROWN ON MUCK SOIL IN THE GREENHOUSE

0% N	661.6	0% P	302.8	0% K	653.3
4% N	677.5	8% P	868.7	16% K	725.7
8% N	712.5	16% P	880.1	32% K	672.6

The difference required for significance is 44.3. Nitrogen applications did not show any great improvement in yield except towards the end of the growing season, when the double application gave a significant increase over the zero treatment.

From February 9 until harvest, the addition of 8% of phosphorus gave a very marked increase in the size of the plants, but the double application did not make any improvement in yield.

The only effect due to the addition of potash was increased height at harvest when 16% gave a significant increase over the zero treatment. At the other 3 dates potash did not increase the height of the plants grown on muck soil.

According to the survey conducted by McKibbin and Stobbe (8) in the Sherrington-St. Clothilde area whence came the muck soil used in the experiment, the values for potash content of the soil ranged from 0.007% to 0.250%.

A test made by Morgan's Universal Soil Testing System (9), which gave a reading of less than 150 lbs. per acre, confirmed the fact that the soil was very low in potash. The addition of potash did not greatly increase the size of the plants. As previously shown in connection with the sand cultures, potash is extremely necessary for good growth of celery, yet on the muck soil used in this experiment, the plants apparently did quite well without a large application of potash.

Figure 2 shows the size of the plants in the 0-0-0, 0-0-1, and 0-0-2 treatments at harvest. The background is laid out in 2-inch squares.

Figure 3 shows the effects of adding phosphorus to the treatments in Figure 2. Figure 4 represents the results obtained by adding nitrogen to the treatments in Figure 2. The increase in size is almost negligible.

As shown in Figure 5, the addition of phosphorus to the treatments represented in Figure 4 resulted in a very great increase in growth.

The above results seem hard to believe of plants grown on muck soil since crops, especially celery, usually respond favourably to applications of potash. To check these results, celery plants were transplanted into 1-gallon crocks containing muck soil from 2 widely different sources and in different stages of decomposition. Fertilizers, representing 5 different treatments, were applied. In the following table, the columns with the heading "A" are the total of the measurements of 3 plants grown on muck soil obtained from the Agronomy Department, Macdonald College, while column "B" represents growth on muck soil from Ste. Clothilde de Chateau-guay.

TABLE 8—TOTAL HEIGHT IN CMS. OF THREE PLANTS PER TREATMENT ON MUCK SOIL FROM TWO SOURCES

Treatment	April 24		May 11		May 27	
	A	B	A	B	A	B
1-0-1	13.1	20.2	18.0	45.9	38.1	81.8
1-0-2	14.1	19.2	16.6	54.0	31.1	88.9
1-1-0	45.2	48.6	90.8	93.7	103.5	102.9
1-1-1	43.1	43.0	87.8	89.2	102.3	94.7
1-2-0	44.9	46.7	89.3	91.0	95.9	99.0

These figures show the very great increase in the height of the plants when phosphorus was applied. There was a slight decrease in size of the plants when potash was added to the nitrogen and phosphorus. The increase in size of plants by substituting phosphorus for potash was not as evident in the plants grown on muck from source "B" as it was in the greenhouse experiment on muck soil which has already been described. However, some increase occurred.

The effect of nitrogen, phosphorus and potash on leaf count is similar to that shown for these 3 elements on height of plants. Hence it would seem that there is a very definite relation between the size of the plant and the number of leaves produced.

Experiment 3

Effect of treatments on the plants

Mineral soil, as would be expected, gave very different results from the fertilizer treatments from those which were obtained on the muck soil.

TABLE 9.—EFFECT OF NITROGEN, PHOSPHORUS AND POTASH AT HARVEST ON THE HEIGHT OF PLANTS GROWN IN THE GREENHOUSE ON MINERAL SOIL

0% N	859.5	0% P	769.1	0% K	907.7
4% N	780.8	8% P	825.7	16% K	790.1
8% N	754.6	16% P	800.1	32% K	697.1

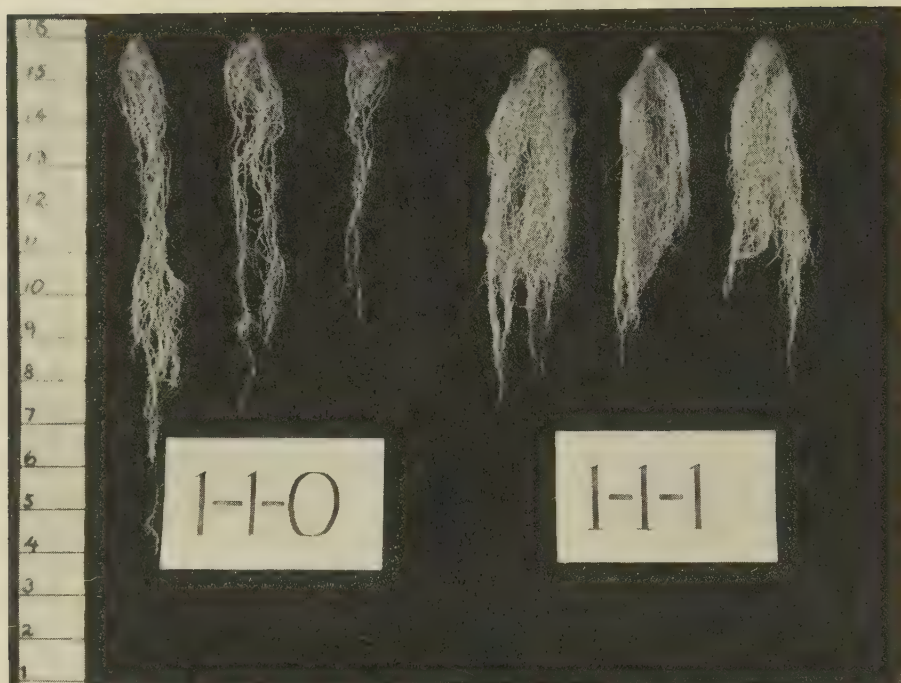


FIGURE 1. Showing the effect of the lack of potash on the roots (left) as compared with roots which had received potash (right).

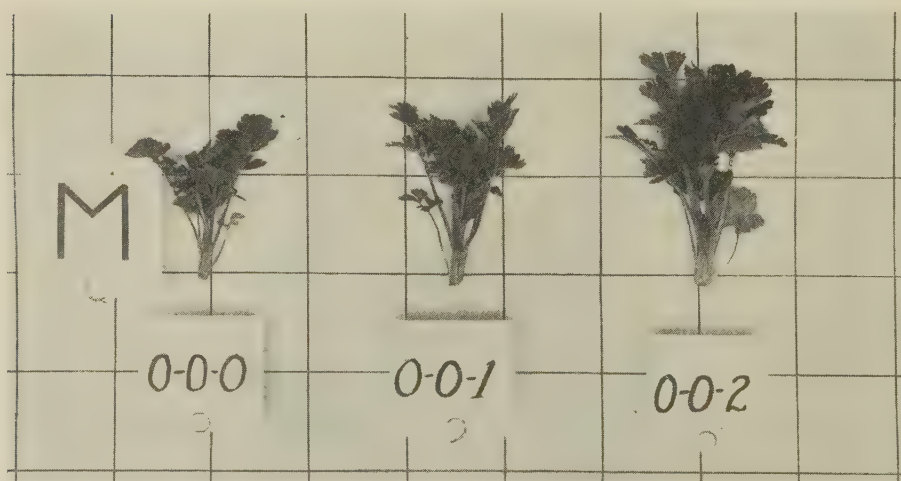


FIGURE 2. There is very little difference in plant size between the presence and absence of potash. The plants are small in the absence of nitrogen and phosphorus.



FIGURE 3. The addition of phosphorus has greatly increased the size of the plants. (Compare with Figure 2.) Potash in addition to phosphorus has increased the body of the plants somewhat.

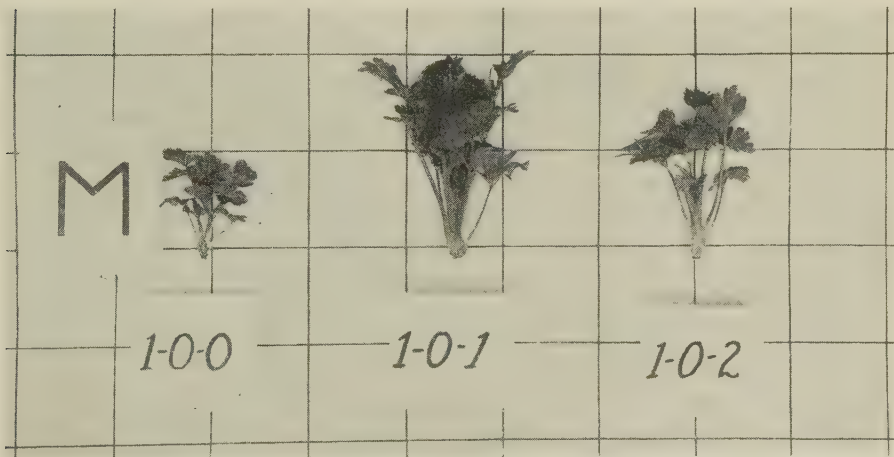


FIGURE 4. Nitrogen alone and in combination with potash did not result in large plants.



FIGURE 5. When phosphorus is applied to the series represented in Figure 4, growth is very substantially increased. This shows the relative importance of phosphorus as compared with the other two elements.

The difference required for significance is 85.50. Eight per cent nitrogen gave significant decreases in height on March 8 and 22. On the first two dates (February 9 and 22), the decrease reached almost the odds of 20 : 1.

On February 9 and 22, the addition of phosphorus increased the height. On March 8, the increase was hardly significant, while at harvest, phosphorus did not produce any significant difference.

Potash gave the most striking results of all. Good yields were obtained without any potash. The addition of 16% decreased the yields significantly while a further addition of 16% gave yet another significant decrease. Figure 6 shows the type of decrease observed. It must be mentioned that this is the most outstanding decrease due to potash additions but serves well to illustrate the point, since other potash treatments show the same type of decrease.

Nitrogen did not affect the leaf count markedly, though it had a slightly depressing influence. The addition of 8% of phosphorus increased the number of leaves, while 16% decreased the number. An increase of potash

to 16% and to 32% decreased the number of leaves very markedly each time.

The leaf count and the height measurements would suggest that the mineral soil already contained sufficient nitrogen and potash. Further additions of these 2 elements decreased the yields. An 8% application of phosphorus improved the size. Since greenhouse compost, containing manure, was used, these results would indicate that this mineral soil, with a good application of manure, would require 800 lbs. of superphosphate to yield a good crop of celery. It is quite possible that a small application of phosphorus might have given a greater response since there are some indications that an increase of phosphorus somewhat decreased the yield.



FIGURE 6. On mineral soil the addition of potash had a detrimental effect on yield. The plants did very well without an application of potassium.

DISCUSSION

Four per cent nitrogen, 8% phosphorus and 16% potash at the rate of one ton of fertilizer mixture (4-8-16) per acre gave the best results with celery growing on quartz sand.

Potash applications did not bring about any improvement during the first 5 weeks. Apparently the plants had stored up sufficient potassium during the seedling stage to tide them over a part of the time when they were receiving no potash in the nutrient solution. This is in keeping with the results of Blake et al. (1) and Davis et al. (3).

Potash deficiency symptoms in celery as brought out in this work compare somewhat with those in potatoes as pointed out by Rohde (10); *e.g.*, yellowing of older leaves, dwarfing of the plant, a weakened root system, and a marked development of deficiency symptoms in the presence of an abundance of nitrogen.

There seems to be no question but that nitrogen, phosphorus and potash are necessary for the formation of strong, healthy, well-developed root systems.

Since the quartz sand contained little, if any, of the elements necessary for growth, the results derived here show what celery actually requires for optimum growth. The varying results on the muck and mineral soils show what the plants require for growth on those particular soils. Hence if potash does not seem to be required in the fertilizer mixture, as shown by the muck and mineral soil plots in the greenhouse, it is no criterion that the plant does not require and use potash.

CONCLUSIONS

1. Plants were grown in quartz sand and fed weekly with nutrient solutions. The results indicated that the equivalent of one ton per acre of 4-8-16 fertilizer mixture gave the best results.

2. Root systems were affected by the deficiencies of nitrogen, phosphorus and potash, being small and brownish.

3. Potash deficiency tended to produce poorly developed root systems with few rootlets.

4. Phosphorus was the limiting factor on muck soil in the greenhouse, while additions of nitrogen and potash to mineral soils adversely affected growth.

5. In many instances, increasing phosphorus beyond a certain limit had a detrimental effect on growth.

6. In some of the studies, an increase of potash did not improve the yield or quality, but it had no detrimental effect on growth, except when it was applied to the mineral soil plots in the greenhouse.

7. A proper balance of nitrogen, phosphorus and potash is required to give the best results. This balance can be ascertained only by trial on the different types of soil and under the different climatic conditions which are likely to exist from year to year.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to those who made this work possible, more especially to Prof. H. R. Murray of the Horticulture Department, who suggested the problem and gave assistance in the greenhouse studies; to Prof. R. Summerby of the Agronomy Department, for

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RASPBERRY NUTRITION¹

IV. CAN THE CUTHBERT RASPBERRY BE SAVED IN COASTAL BRITISH COLUMBIA?

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As part of a program undertaken to ascertain the causes of raspberry failures in coastal British Columbia, the following studies on raspberry nutrition and management were carried out in the Plant Nutrition Section of the Department of Horticulture, The University of British Columbia.

The Cuthbert has for many years been British Columbia's outstanding raspberry. It is still preferred by the trade. Most shippers, canners, and the trade generally refuse other raspberries if Cuthberts are available. Because of its general merit, growers were loth to think of discarding the Cuthbert and planting other varieties. Nevertheless, many of them have been advocating its general abandonment, claiming that it can no longer be grown satisfactorily in British Columbia. The present investigation was undertaken in part to see whether the Cuthbert should be discarded in favour of some other variety, or whether it could be grown profitably provided that some system of good management were practised.

MATERIALS AND METHODS

Young raspberry plants (suckers) of the Cuthbert variety were used throughout the investigation. These plants were obtained from a source recommended by Dominion and Provincial Government agricultural officials as being the best source in the Fraser Valley from which to obtain stock plants.

The project was divided into four phases, as follows:

A. Sand Pot Cultures

The plants were set out in large pots filled with well-washed sand, in the spring of 1937. These plants were fed with various nutrient solutions, in each of which, other than the checks, one of the nutrients considered necessary to plant growth was either omitted or given in excess. Hoagland's nutrient solution was used as the basis, and by varying this solution the treatments given were as follows:

- Complete nutrient solution
- Nitrogen—deficient
- Phosphorus—deficient
- Potassium—deficient
- Calcium—deficient
- Sulphate—deficient
- Nitrogen—excess, 5x

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Phosphorus—excess, 5x
Potassium—excess, 5x
Calcium—excess, 5x
Complete plus boron, 5 p.p.m.; manganese, 2 p.p.m.; and zinc, 1 p.p.m.
Complete plus boron, 5 p.p.m.
Complete plus manganese, 2 p.p.m.
Complete plus zinc, 1 p.p.m.
Complete plus aluminum, 10 p.p.m.

The object of this experiment was to see whether symptoms similar to those appearing in affected field plantings could be produced artificially.

During the spring of 1938, the plants were carefully removed and half of those receiving each treatment were placed in a 50/50 mixture of the original sand and peat moss; the others were replaced in the original sand.

B. Soil Pot Cultures

Plants were set out in large pots filled with a heavy clay soil taken from a notoriously poor raspberry plantation located at Hatzic in the Fraser Valley, in 1937. These plants were treated with different kinds of fertilizing materials, including micro elements, to note whether any beneficial response could be obtained. The materials used were as follows:

Check—soil as taken directly from the field.
Soil sifted to remove foreign matter, decayed roots, etc.
Soil steam sterilized.
Ammonium sulphate applied at the rate of 800 lb. per acre.
Ammonium sulphate plus iron sulphate, applied at the rate of 250 and 50 lb. per acre respectively.
Iron sulphate applied at the rate of 50 lb. per acre.
Potassium sulphate applied at the rate of 200 lb. per acre.
Manganese sulphate applied at the rate of 25 lb. per acre.
Zinc sulphate applied at the rate of 25 lb. per acre.
Free sulphur applied at the rate of 200 lb. per acre.
Gypsum applied at the rate of 2000 lb. per acre.
Dry lime sulphur (spray material) applied at the rate of 500 lb. per acre.
Boron applied at the rate of 25 lb. per acre.
Copper lime dust applied at the rate of $\frac{1}{4}$ oz. per plant.
Copper carbonate applied at the rate of $\frac{1}{4}$ oz. per plant.
Cheshunt compound applied at the rate of 1 quart per plant.
Ferrous ammonium sulphate $\text{Fe}(\text{NH}_4)_2 (\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ at the rate of 150 lb. per acre.
Check—a greenhouse compost used in the U.B.C. greenhouses.

C. Field Plots

In the spring of 1937 a field plot of somewhat over one acre was planted on the horticultural grounds at the University of British Columbia, in order to determine the effects of various fertilizer, cover-crop and cultural treatments under field conditions, in contrast to the above controlled pot experiments. The soil is a fairly uniform glaciated loamy sand, with a very low water-holding capacity. It has a reaction of pH 5.70, a field capacity of about 17% moisture, and plants wilt in it at around 12% moisture.

The procedure was as follows:

Plot A

Fertilizer Treatments (clean cultivation)

In order to ascertain the effect of various fertilizer applications, treatments were as indicated below. Each treatment was separated by a buffer row. The basic fertilizer used was 5-10-5 at the rate of 800 lb.

per acre, with the exception of the ammonium sulphate plot. All plots were the same size.

Check

Complete fertilizer (5-10-5)

Superphosphate plus muriate of potash (nitrogen-deficient)

Ammonium sulphate plus superphosphate (potash-deficient)

Ammonium phosphate (16-20-0) plus muriate of potash plus free sulphur (calcium deficient).

Ammo-Phos. plus muriate of potash

Complete (5-10-5) plus boron at the rate of 25 lb. per acre

Complete plus manganese at the rate of 15 lb. per acre

Complete plus sulphur at the rate of 200 lb. per acre

Complete plus gypsum at the rate of 500 lb. per acre

Ammonium sulphate only at the rate of 800 lb. per acre

Ammonium sulphate plus iron sulphate at the rate of 250 and 50 lb. per acre respectively.

Magnesium sulphate at the rate of $1\frac{1}{2}$ oz. per plant

Plot B

Cover-crop Treatments

The object of this experiment was to determine the value of cover-cropping as a practice in raspberry culture. The plot was divided into sections and each section was seeded to clover, rye, alfalfa, soy-bean, followed by corn and vetch respectively. A clean-cultivated section was also left as a check.

Nitrogen Applications at Different Times of the Year

In order to determine the best time of the year to apply nitrogen, each of the sections in Plot B was subdivided vertically into 4 series:

Series 1 received a complete fertilizer, 5-10-5, in March.

Series 2, 3 and 4 all received an 0-12-10 fertilizer in March as a basic application. Series 2 then received ammonium sulphate in May, Series 3 received ammonium sulphate in July, while Series 4 received ammonium sulphate in September. As before, the 5-10-5 fertilizer at the rate of 800 lb. per acre was used as the basic fertilizer, and equivalent amounts were used in the 0-12-10 application.

The Effect of Liming Raspberries

It was desired to evaluate the use of lime on raspberry plantings on the light upland soils which are typical of many areas in British Columbia. In order to do this, the sections of Plot B were divided horizontally. The upper half did not receive lime, while the lower half received an application at the rate of 2,000 lb. hydrated lime per acre.

Thus it was anticipated that in Plot B the best cover crop to use, the best time of the year to apply nitrogen, and the response of raspberries to liming under the conditions of the experiment could be determined, and that the inter-relations of one to the other would be elucidated.

Experiments with Peat Moss

In the spring of 1938 a trench was dug and peat moss to a depth of 3 to 4 inches was scattered on the bottom and worked into the soil. New plants were set out in this trench. One bale of peat was used for a 90-foot row. Peat was also dug in around various plants scattered throughout the plots. (Magnesium sulphate was also dug in around several plants throughout the plots, at the rate of 4 oz. per plant.)

D. Samples of Fraser Valley Soil and Raspberry Canes

To correlate the work further with conditions throughout the Fraser Valley, samples of canes and the soil on which they were growing, were collected and brought in to the laboratory for analysis. Similar samples were also sent in directly by growers.

RESULTS OF EXPERIMENTS

A. Sand Cultures

During the year 1937 only the plants which received the luxury feeding of phosphorus showed a marked increase in growth over the check plants. They were outstanding (Figures 1 and 2). The nitrogen-deficient, phosphorus-deficient and sulphur-deficient series showed marked deficiency symptoms (Figures 3 and 4) similar to those exhibited by certain field plantings which have been observed.

These symptoms are quite in accord with observations on other plant material reported by other workers (1, 2, 3, 7).

Nitrogen deficiency caused small, stunted plants with small, yellowish green leaves, which later showed excessive anthrocyan pigmentation.

Phosphorus deficiency initially caused a dark-green leaf, which soon showed anthrocyan pigmentation on the underside of the leaf. A purpling of both stems and leaves became pronounced. Plants were small and weak.

Sulphur deficiency was indicated by a yellowish chlorosis of the leaves,

FIGURES 1 AND 2. One-year-old Raspberry Plants grown in Sand Cultures showing the effects of mineral excesses and deficiencies.



FIGURE 1. Left: excess phosphorus. Centre: excess nitrogen. Right: complete nutrient.



FIGURE 2. Left: excess calcium. Centre: excess potash. Right: complete nutrient.

FIGURES 3 AND 4. One-year-old Raspberry Plants grown in Sand Cultures showing the effects of mineral excesses and deficiencies.



FIGURE 3. Left: sulphur deficient. Left centre: phosphorus deficient. Right centre: nitrogen deficient. Right: complete nutrient.



FIGURE 4. Left: calcium deficient. Centre: potash deficient. Right: complete nutrient.

first starting along the veins. The leaves became very papery. Fair growth was made, but the canes were very slender.

Potash deficiency did not develop until late in the season, but when it did develop it did so rapidly. It was characterized by a bronze spotting and scorching of leaf tips and edges.

The series which received additions of micro-elements—boron, manganese, zinc, copper, etc.—showed some, but no really significant increase in growth (Figures 5 to 7).

During 1938, that is, the second year after planting, the best specimens were found in the series receiving complete nutrient solution, complete nutrient plus boron, manganese and zinc, and complete nutrient plus boron. What appeared to be some form of mosaic ran through all the series, with the exception of the above-mentioned.

In every case the plants set out in the sand/peat mixture showed greater and more vigorous growth than the correspondingly treated ones in the sand alone.

B. Soil Pot Cultures

None of the plants in this series were normal, but both years the sterilized pots produced the best plants. In 1938 the sifted soil, and the gypsum, borax, copper-lime dust and cheshunt compound treatments produced fairly good cane growth. Plants in all other series continued to be stunted and weak, with small reddened leaves.

FIGURES 5 - 7. One-year-old Raspberry Plants grown in Sand Cultures. Showing the effects of additions of micro-elements to the complete nutrient.



FIGURE 5. Left: complete + boron. Centre: complete + boron, manganese and zinc. Right: complete nutrient.



FIGURE 6. Left: complete + zinc. Centre: complete + manganese. Right: complete nutrient.



FIGURE 7. Left: complete + aluminum. Centre: phosphorus deficient. Right: complete nutrient.

Observations made on the roots at the time of re-potting in the spring of 1938 were as follows:

Check—roots poor.
 Sterilized soil—good root formation.
 Ammonium sulphate—moderate rooting.
 Ammonium sulphate plus iron sulphate—good root formation.
 Iron sulphate—moderate root formation.
 Potassium sulphate—very poor rooting.
 Manganese sulphate—moderate rooting.
 Zinc sulphate—stunted roots.
 Gypsum—good roots.
 Lime sulphur—long, slender roots, fairly good.
 Free sulphur—stunted roots, sulphur not oxidized.
 Boron—roots poor.
 Copper-lime dust—moderate rooting.
 Copper carbonate—moderate rooting.
 Cheshunt compound—good roots.
 Ferrous ammonium sulphate—good roots.

The peat/sand mixture in 1938 without exception increased growth from 10 to 100%.

C. Field Plots

Fertilizer Treatments (clean-cultivated)

Canes in this plot made poor growth in 1937, but in 1938 made excellent growth. They were all irrigated in 1938, and the splendid response would indicate that a plentiful moisture supply is of paramount importance in raspberry production.

The nitrogen-, phosphorus-, and potash-deficient rows showed distinctive deficiency symptoms corresponding to those in the sand cultures.

The greatest growth resulted in canes receiving a complete fertilizer (5-10-5) plus sulphur, and complete plus gypsum treatment.

Those plants which received magnesium sulphate also responded with strong cane growth, as did the rows treated with peat.

That a definite response to fertilizer treatments was obtained can be observed from Table 1.

TABLE 1.—YIELD OF RASPBERRIES IN RELATION TO FERTILIZER TREATMENTS, 1939

Treatment	Yield (lb.)
Ammonium phosphate plus muriate of potash	195
5-10-5 plus free sulphur	169
5-10-5 plus gypsum	159
Ammo-Phos plus muriate of potash plus sulphur	154
5-10-5 plus boron	149
Ammonium sulphate only	131
5-10-5 plus manganese	128
5-10-5	106
Ammonium sulphate plus iron sulphate	104
Superphosphate plus muriate of potash	76
Ammonium sulphate plus muriate of potash	74
Ammonium sulphate plus superphosphate	65
Check	64

The benefit of sulphur-carrying fertilizers and ammonium phosphate is quite pronounced.

The above yields can also be taken as indicative of growth response.

Cover-crop Treatments

In this section the clean-cultivated patch gave the best response. This was followed by the vetch cover crop. The yields from these plots are indicative of the response to the various treatments.

TABLE 2.—YIELD OF RASPBERRIES IN RELATION TO COVER-CROP TREATMENTS

Treatment	Yield (lb.)	Treatment	(Yield (lb.))
Clean cultivation	592	Soy-bean cover crop	201
Vetch cover crop	295	Alfalfa cover crop	143
Clover cover crop	227	Rye cover crop	105

Nitrogen Applied at Different Times of the Year

To date this experiment indicates that in the light upland soils of coastal British Columbia, the spring is the best time to apply nitrogen, if only one application a year is to be given.

TABLE 3.—YIELDS OF RASPBERRIES IN RELATION TO NITROGEN APPLICATIONS AT DIFFERENT TIMES OF THE YEAR

Fertilizer treatment	Yield from cover-crop treatment						
	Clean cultivation	Clover	Alfalfa	Rye	Vetch	Soybean	Total
5-10-5 April	174	45	67	40	127	52	504
0-12-10 April Am. sulphate May	196	88	27	24	97	98	530
0-12-10 April Am. Sulphate July	138	53	40	28	32	65	356
0-12-10 April Am. Sulphate Sept.	83	39	9	13	38	27	209

The April application of the complete fertilizer, 5-10-5, and the basic application of 0-12-10 in April followed by ammonium sulphate in May, gave the best results. Fall fertilizing with nitrogen does not appear to have given much benefit.

The Effect of Liming Raspberries

The results of liming the plots are shown in Table 4.

This table clearly indicates that liming has proved detrimental in this experiment. This is accounted for by the fact that the reaction of the unlimed plots is not unfavourable to raspberry production (pH 5.7). Moreover, soil analyses showed that available phosphorus was lowered by the liming (8).

TABLE 4.—THE INFLUENCE OF LIMING ON YIELDS OF RASPBERRIES

	Yield from cover-crop treatment						
	Clean cultivated	Vetch	Clover	Alfalfa	Rye	Soybean	Total
Limed	244	131	97	66	50	129	718
Unlimed	348	164	129	77	54	112	885

Experiments with Peat

The row established over peat is not yet in full bearing, so comparative yields cannot be reported. The healthy vegetative condition of the canes has been reported on above.

D. Samples of Canes and Soil from Outside Points

The causes of raspberry failure in the patches from which samples were collected and sent in by growers for analysis, were many. These have been reported in a previous paper, and further work substantiates the former findings (5).

CONCLUSIONS

The raspberry decline problem in coastal British Columbia in many cases can be attributed to nitrogen, phosphorus, sulphate and potash deficiencies. The first two are the most common. The raspberry responds to luxury feeding of phosphorus in particular.

Nitrogen, phosphorus, potash and sulphate deficiency can readily be detected in the raspberry by foliar diagnosis. Growers should become more familiar with these deficiency symptoms than they are at present.

There is a suggestion that the plants in this experiment which received the micro-elements were more resistant to mosaic disease than those which did not receive them. Further work along this line would be warranted. That mosaic is a definite factor to be contended with means that a rigid selection of plants must be exercised. Some permanent reliable source of healthy stock plants would be of great benefit to the raspberry grower.

The observations on root formation in the badly depleted Hatzic soil, and the indications of root stimulation from copper-, iron- and sulphur-containing compounds may be considered evidence of the value of these substances in such a soil. Whether these compounds acted in this case as stimulants or as soil disinfectants cannot be stated.

The beneficial effect of peat throughout is noteworthy. This could be due to the increase of aeration in the heavy Hatzic soil, and also to the increase in the water-holding capacity of the soil. However, the applications of peat used in order to accomplish this effect were heavy.

The results from the field plots definitely indicate that water is probably the chief limiting factor in raspberry plantings in the light, upland soils of British Columbia's coastal regions. Plants which only struggled along without irrigation, flourished luxuriantly under irrigation, with the same fertilizer treatments.

The B.C. coastal soils are, in the main, relatively low in phosphorus. Nevertheless, the form in which this element is applied is significant in raspberry nutrition. Ammonium phosphate, for instance, gives a good response. It may be said in general that phosphorus should be applied in combination with, or soon followed by, nitrogen, and preferably in some sulphur-carrying fertilizer. The soils in question are low in sulphates (5) and hence the plants respond to sulphates. This high phosphorus requirement of the raspberry was established in the sand culture experiments reported, and is again reflected by the detrimental effects of liming, which lowered the available phosphorus of the soil (8).

The clean-cultivated plots gave better results than the cover-crop series. It must be borne in mind, however, that these plots were well fertilized and watered. For the majority of growers, where economy in fertilizers is necessary and where no irrigation is practised, the use of cover crops is still to be recommended. In such cases the water-holding capacity of the soil must be increased, and the added organic matter of the cover crops will increase the water-holding capacity of the soil as well as reduce leaching losses of the added nutrients. Of the cover crops tried, vetch has proved superior to the others.

It has been shown to date that nitrogen applied early, in a complete fertilizer, or a basic application of fertilizer in the form of 0-12-10 followed by an application of nitrogen in early May, gave the best results. It must be recalled, however, that the plants which received nitrogen in July and September did not receive any other nitrogen. During the period of rapid growth, when nitrogen is used heavily, they did not receive any. The writer is of the opinion that while a spring application of nitrogen is essential, later applications, as well as the one in the spring, could be used to advantage (4). A sound practice would be to use either a low-nitrogen complete fertilizer or an 0-12-10 fertilizer in early spring, followed at intervals with light applications of ammonium sulphate. Careful foliar diagnosis will indicate when this should be applied. Fall fertilization with nitrogen does not appear to be advisable. The nitrogen, in all probability, is leached away by the fall rains before it can be of much benefit to the plants.

Liming did not seem to be of much value. It was actually detrimental. This can be accounted for by the fact that the reaction of the unlimed plots, pH 5.7, is not unfavourable to raspberry production. Soil analyses, moreover, showed that the available phosphorus was lowered by the liming. This danger from liming, even though the reaction may indicate a need for lime, has already been pointed out (5).

While peat is obviously of advantage in that it adds organic matter and increases the water-holding capacity of a light soil, the amounts necessary to do this make its use impracticable for the average grower, unless he be located where he can obtain it merely for the cost of hauling it himself. Most growers must rely on cheaper methods to obtain organic matter, such as cover cropping, or the use of some mulching material.

There seems to be no one cause from which all the declining raspberry plantings are suffering. It is a case of individual diagnosis and remedy for each section, and in many cases for each plantation or part of a plantation. General recommendations are inadvisable.

The conclusion is reached that the foregoing experiments have definitely established the fact that the Cuthbert raspberry can still be grown profitably in coastal British Columbia, provided that it receives proper cultural treatment. It is essential to use healthy planting stock and a continuous, reliable source of such stock is needed. There are no grounds at present on which to discard the Cuthbert raspberry in B.C. or discourage its planting. It is still our best berry.

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DORMANCY IN WHEAT AND BARLEY VARIETIES IN RELATION TO BREEDING¹

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INTRODUCTION

Modern plant breeding methods involve consideration of an ever-increasing number of characters. As standards become more exacting and competition more severe, it becomes necessary to perfect varieties in particulars which had previously been thought of minor importance or non-genetical. The dormancy of grain varieties is a character that only recently has achieved a position of breeding significance.

Dormancy, or "after ripening"⁴ of grain, is important in those regions where prolonged wet weather may occur at the time the crops ripen. Occasionally on the plains of Western Canada, wet harvest weather causes large losses due to sprouting of stooked and windrowed grain waiting to be threshed. The losses are particularly severe in the cooler moister areas. Furthermore, some varieties suffer far more damage than others.

Economically it is desirable to have varieties which remain dormant for several weeks following maturity. Marquis, which for years has been the most extensively used wheat variety in Western Canada, has a long dormancy period and is popularly considered highly resistant to after-harvest sprouting. There are, however, other standard varieties which do not possess high "sprouting resistance." From the viewpoint of both the farmer and the plant breeder, it seemed desirable at this time to make a study of dormancy in varieties which are being used commercially or as parental material in crosses.

LITERATURE REVIEW

The literature on dormancy is fairly extensive, and it is only necessary here to consider a few of the more pertinent papers.

Harrington (3) compared the effect of moist conditions at harvest time on varieties of durum and bread wheat which were stooked in the field. In the 1927 experiment the varieties were ranked from high to low resistance to sprouting as follows: Marquis 70, Kitchener, Red Fife, Red Bobs, Reward, Renfrew, Pelissier (durum), Mindum (durum), Early Red Fife, Kubanka (durum), Quality, Ruby, and Garnet. In 1931 the order of resistance to sprouting was Marquis, Reward, Ceres, and Garnet.

Deming and Robertson (1) studied the dormancy of 7 varieties of wheat, 13 of barley, and 3 of oats. The varieties were harvested when ripe and plantings made in moist sand each day after maturity for 60 days in

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⁴ After-ripening is a state of dormancy of the embryo and is used synonymously with the term "dormancy" in this paper. "After-ripening" refers to the dormancy of a mature seed in the presence of conditions favouring germination and no apparent physical impediments (such as hard seed coat) to germination.

1928, and 40 in 1929 and 1930. If a seed did not emerge 10 days after planting, it was considered to be dormant. The wheat varieties ranged from Marquis with considerable dormancy to 3 varieties with no dormancy. The barley varieties showed a range from no dormancy to dormancy for 11 days after harvest. Two oat varieties germinated immediately but the third was dormant for 27 days.

Scholz (5) tested 143 varieties of bread wheat and 6 durum varieties. Germination tests were started immediately after harvest and continued at 10-day intervals using moist filter paper. The durum varieties used had a longer after-ripening period than the bread wheats. No relation was found between the length of the after-ripening period and either spring or winter habit or earliness of ripening. After-ripening was not found to be associated with the moisture content of the grain.

Freistedt (2) conducted very extensive tests over a number of years on the dormancy of both spring and winter barleys. He used moist filter papers for the germination tests; he also used sheaves kept in a moistened chamber. A number of Japanese varieties proved to have a long after-ripening period. Winter barleys were tested for germination from the milk to the fully-ripe stage. In a genetic analysis conducted on the F_2 of 4 crosses of spring barley, dormancy proved recessive. In one cross 1 factor seemed involved, and in the other crosses 2 factors.

Navolotskii and Navolotskaja (4) demonstrated injury to the seed as a result of germination in the ear. *Triticum durum* tended to germinate readily in the ear. *T. persicum* under excessive humidity was also defective in this respect, while *T. dicoccum* was resistant to sprouting.

MATERIALS AND METHODS

1. In the fall of 1937, a preliminary test of dormancy was conducted at the University of Saskatchewan on 5 varieties of bread wheat, Marquis, Garnet, Reward, Thatcher, and Reliance, and 1 durum variety, Mindum. Heads of all of the varieties were collected on the same day within an area of 5 acres. Each head taken was discarded unless it was at the stage of maturity when the lower kernels are indented with difficulty by the thumb-nail.¹ The seeds were rubbed out from each head on the day it was collected.

Petri dishes containing sand were used as germinators. A single germination test of each variety consisted of 2 dishes containing 50 seeds each. The sand in the dishes was kept as uniformly moist as possible. The temperature of the room varied from 20° to 22° C. On the day that the varieties were harvested (August 3), a germination test was commenced. Further tests were started after this at intervals of 4, 8, 12, 16, 21, 26, and 36 days after maturity. Germination counts were made at 2, 4, 6, and 30 days after establishing a test. A seed was considered germinated when the roots had emerged $\frac{1}{8}$ -inch.

¹ This is a standard test of maturity which is reliable and widely used.

2. In 1938 the experiment was enlarged to include more varieties of wheat and some barley varieties as well. Following are the wheat varieties used: *T. vulgare*—Marquis, Reward, Garnet, Thatcher, Apex (Sask 1703), Apex (Sask 1789), Renown, and Reliance; *T. durum*—Mindum, Golden Ball, and Pelissier; *T. persicum*—Black Persian. The barley varieties were: 2-rowed awned—Hannchen and Rex; 6-rowed awned—Regal, O.A.C. 21, and Trebi; 6-rowed hooded—Sixty-Day and 2 hooded hybrids. One of these hybrids, designated TC. III-36-46, was a selection from the cross Trebi × Colsess. The other, called TS. III-36-9, was a selection from the cross Trebi × Sixty-Day.

As in 1937, no spikes were used in either wheat or barley unless the lower kernels of the spike were indented with the thumb-nail with difficulty. All the barley varieties were taken on one day, August 5. Similarly, all the wheat varieties were collected on August 11. The heads were threshed by rubbing the seeds out. In order to harden them the kernels were kept dry for a day previous to starting the germination test.

Throughout the 1938 experiments, duplicate samples of 50 seeds each were used for testing each variety. As already mentioned, the first germination tests of wheat and barley were carried out at the hard-ripe stage. Further germination tests were started at regular intervals, as indicated in Table 2. Germination was carried out on a basement floor in a greenhouse. Sand was spread evenly on the floor to a depth of one inch and moistened. The seeds were placed on this, and a petri dish put over them. The sand was kept moist by watering with a sprinkling can every few days. Excessive moisture was drained off. The moisture conditions throughout the tests tended to be quite uniform. The temperature of the sand ranged from 16° to 17° and that of the atmosphere from 17° to 18° C.

It will be noted that the sand temperatures were 4° to 5° lower in the 1938 tests than in the 1937 tests. It is possible that the after-ripening period of some varieties was slightly shortened in 1937 as compared with 1938 due to this temperature difference. It is considered that this is a relatively unimportant point, especially since the data from the 2 years was considered separately in making varietal comparisons.

1. RESULTS FROM THE 1937 TEST ON WHEAT

The results of the 1937 wheat study are presented in Table 1. All varieties maintained a 2-day dormancy from maturity until 26 days after maturity, with the exception of Garnet, which showed 15% germination 12 days after maturity and increasing amounts thereafter, and Reliance, which showed 12% germination after 16 days. Mindum showed little 4-day dormancy and practically no 6-day dormancy at any time after maturity. Garnet showed only 21% germination in 4 days immediately after maturity, but in the tests started subsequent to 4 days after maturity this variety showed no 4-day or 6-day dormancy. Reliance germinated at 4 and 6 days to a much lower extent than Garnet until 12 days after maturity, but thereafter behaved like Garnet. Reward and Thatcher behaved alike as to 4-day dormancy, holding it well until 8 days after maturity. But Reward germinated in 6 days to a much less extent than Thatcher until 8 days after maturity. Marquis germinated least readily of all the varieties and excelled the nearest competitor, Reward, by resisting germination at 2 days until after 21 days after maturity.

Summarizing the 1937 tests shows: (1) Mindum with the greatest 2-day dormancy and very little dormancy for more than 2 days at any time after maturity; (2) Garnet with relatively little dormancy excepting for 2 days during the first 12 days after maturity; (3) Reliance with distinctly more dormancy than Garnet; (4) Thatcher with 4-day dormancy continuing until 8 days after maturity; (5) Reward and Marquis with 6-day dormancy continuing for 8 days after maturity. Thus a short wet spell would be expected to affect Mindum the least and Garnet the most, whereas a longer wet spell would injure Mindum the most and the other varieties in the order Garnet, Reliance, Thatcher, Reward and Marquis.

TABLE 1.—COMPARISON OF SIX WHEAT VARIETIES FOR GERMINATION AFTER MATURITY IN 1937*

Days after maturity	Days after start of germination test	Marquis	Garnet	Reward	Thatcher	Reliance	Mindum
				per cent germination			
0	2	0	0	0	0	0	0
	4	0	21	0	0	13	63
	6	0	54	3	37	35	92
	30	27	98	36	96	82	95
4	2	0	1	0	0	0	0
	4	0	44	0	0	14	51
	6	0	77	3	42	47	91
	30	26	99	38	94	83	98
8	2	0	0	0	0	0	0
	4	4	90	2	0	59	41
	6	8	96	7	28	77	77
	30	45	99	57	97	99	100
12	2	0	15	0	0	0	0
	4	35	98	47	50	61	47
	6	84	98	82	96	98	95
	30	97	98	93	98	100	98
16	2	0	43	1	0	12	2
	4	62	100	100	99	100	31
	6	100	100	100	100	100	92
	30	100	100	100	100	100	97
21	2	2	79	4	1	7	1
	4	98	100	99	91	97	63
	6	100	100	100	98	97	94
	30	100	100	100	100	100	97
26	2	83	95	81	67	86	17
	4	99	97	100	99	100	84
	6	99	98	100	100	100	99
	30	100	100	100	99	100	92
36	2	100	100	100	99	100	92
	4	100	100	100	99	100	99

* Date of maturity—Aug. 3, 1937.

2. RESULTS ON WHEAT HARVESTED AT MATURITY IN 1938

The 1938 results on wheat harvested at maturity are presented in Table 2. A general comparison of these results with those obtained in 1937 reveals for 1938 less complete dormancy immediately after maturity but a tendency for dormancy to continue a few days longer than in 1937.

The three durum varieties behaved in 1938 much as Mindum did in 1937 with very little 4-day dormancy and practically no 6-day dormancy at any time after maturity. It is of interest that immediately at maturity the durums showed more germination in 2 days than at any later period up to 84 days after maturity.

The bread wheat varieties showed much variation. Compared collectively with the durums, the bread wheats maintained more dormancy during the first 8 days after maturity and less thereafter. Reliance was unique in showing practically no dormancy at any time, excepting for 2 days during the period from 4 to 36 days after maturity. Garnet showed a 2-day dormancy for 20 days after maturity and a high degree of 6-day dormancy at maturity, but otherwise resembled Reliance. The remaining varieties, including Marquis, Reward, and those with rust resistance, had distinctly more dormancy. Renown retained much 6 and 30-day dormancy until 20 days after maturity, and Apex 1789 retained dormancy similarly until 12 days after maturity. Marquis, Reward, Thatcher, and Apex 1703 showed much 6-day dormancy 4 days after maturity, but Thatcher resembled Reliance in having practically no 30-day dormancy immediately after maturity. The 4-day germination results show roughly the same varietal differences in dormancy from the 4th to the 20th day after maturity. Subsequent to 20 days after maturity, the 2-day germination results indicate the differences between varieties.

Black Persian, representing the species *T. persicum*, gave results closely resembling those of the bread wheat averages.

The data of Tables 1 and 2 are summarized in Table 3 to show the varieties in approximate ranking for resistance to germination. For the purpose of this summary, germination percentages above 40% were considered to indicate non-dormancy. It is of interest that two of the new rust-resistant wheats, Renown and Apex 1789, ranked highest in 1938, the only year they were tested. Considering both years, the ranking of varieties is identical, excepting that in 1937 Marquis slightly excelled Reward and in 1938 the reverse occurred.

3. RESULTS ON BARLEY HARVESTED AT MATURITY, 1938

The results of the sprouting tests of barley are presented in Table 4. The data show greater relative differences in dormancy among the barley varieties than were found among the wheat varieties. After being under

TABLE 2.—COMPARISON OF DIFFERENT VARIETIES OF WHEAT FOR GERMINATION AFTER MATURITY, 1938*

Days after maturity	Days after start of germination test	<i>Triticum vulgare</i>								<i>T. durum</i>			<i>T. persicum</i>
		Marq.	Rew.	Gar.	That.	A 1703	A 1789	Ren.	Rel.	Min.	Pel.	G. Bl.	Bl. Pr.
					Per cent germination								
0	2	0	0	3	0	1	2	0	29	8	11	10	2
	4	6	2	5	3	6	11	0	88	41	45	64	7
	6	8	7	9	23	9	21	2	92	78	83	93	17
	30	40	15	44	81	33	50	15	95	99	100	100	37
4	2	4	1	10	0	0	2	0	4	1	7	0	5
	4	22	22	50	12	16	10	2	97	49	65	53	20
	6	33	29	56	49	24	18	5	98	84	84	80	24
	30	47	36	80	88	44	36	23	100	100	97	100	33
8	2	0	0	0	0	0	0	0	0	0	0	0	7
	4	58	31	84	39	49	16	17	97	37	17	43	60
	6	69	40	87	55	63	24	25	100	76	62	80	71
	30	77	46	96	92	78	47	41	100	95	87	100	72
12	2	0	0	0	0	0	0	0	0	0	0	0	0
	4	72	65	93	54	64	37	8	96	33	24	32	42
	6	81	72	95	60	71	47	10	100	63	61	83	54
	30	88	74	98	88	76	61	20	100	98	94	93	57
20	2	0	0	6	0	0	0	0	0	0	0	0	1
	4	94	76	98	74	84	69	41	97	52	25	59	77
	6	96	79	100	82	86	72	43	99	71	60	88	82
	30	98	82	100	100	96	81	51	100	97	95	98	83
28	2	19	9	81	3	3	5	5	13	2	1	0	60
	4	100	96	100	99	100	98	84	100	74	55	75	96
	6	100	96	100	99	100	98	86	100	83	87	97	96
	30	100	96	100	99	100	98	94	100	100	95	100	97
36	2	0	0	12	0	0	0	1	0	0	0	0	6
	4	97	99	100	99	93	97	89	99	69	59	75	96
	6	98	99	100	100	98	100	91	100	78	76	87	98
52	2	12	1	50	4	0	3	0	25	0	0	0	20
	4	98	100	100	98	99	97	94	100	22	29	58	98
	6	99	100	100	100	99	99	98	100	42	71	79	99
84	2	65	59	100	48	68	63	92	60	23	15	46	87
	4	100	99	100	100	100	99	100	100	93	68	100	100
	6	100	100	100	100	100	100	100	100	99	97	100	100

*NOTE.—Date of maturity was August 12, 1938.

Key to abbreviations in Table 2.

Marq. — Marquis (Sask. 100)
 Rew. — Reward (Sask. 1003)
 Gar. — Garnet (Sask. 791)
 That. — Thatcher (Sask. 1720)
 A 1703 — Apex (Sask. 1703)
 A 1789 — Apex (Sask. 1789)

Ren. — Renown (Sask. 1735)
 Rel. — Reliance (Sask. 1851)
 Min. — Mindum (Sask. 64)
 Pel. — Pelissier (Sask. 109)
 G. Bl. — Golden Ball (Sask. 1887)
 B. Pr. — Black Persian (Sask. 1801)

TABLE 3.—SUMMARIZATION OF RESULTS ON WHEAT VARIETAL GERMINATIONS AT DIFFERENT DATES AFTER MATURITY IN 1937 AND 1938

Variety	The number of days which elapsed after maturity before exposure to germination conditions for 2, 4, 6 or 30 days, respectively, resulted in more than 40% germination				
	2 days	4 days	6 days	30 days	Rank
1937 Marquis	26	16	12	8	1
Reward	26	12	12	8	2
Thatcher	26	12	4	0	3
Reliance	26	8	4	0	4
Mindum	36	0	0	0	5
Garnet	16	4	0	0	6
1938 Renown	84	20	20	8	1
Apex 1789	84	20	12	0	2
Reward	84	12	12	8	3
Blk. Pers.	84	8	8	8	4
Apex 1703	84	8	8	4	5
Marquis	84	8	8	4	6
Thatcher	84	12	4	0	7
Reliance	84	0	0	0	8
Mindum	84+	0	0	0	9
Pelissier	84+	0	0	0	10
Gold. Ball	84	0	0	0	11
Garnet	28	4	4	0	12

germination conditions for 2 days, Hannchen, Rex, and Sixty-Day showed the most ready germination while TC. III-36-46 and Trebi had the greatest resistance to germination. When a period of between 20 and 36 days had elapsed after ripening, germination in 4 days was slight for TC. III-36-46 and Trebi, moderate for Regal and almost complete for the remaining varieties.

In the 6-day test, Hannchen and Rex germinated readily, but were followed closely by Sixty-Day, TS. III-36-9 and O.A.C. 21, Regal was intermediate and Trebi and TC. III-36-46 came last. Exposure to germination conditions for 30 days resulted in Hannchen and Rex germinating almost completely whether started at maturity or at later dates, but in TC. III-36-46, Regal and Trebi only very gradually achieving this ability to germinate. The other varieties were intermediate.

In general, therefore, Rex and Hannchen possessed practically no after-ripening period, being able to sprout almost completely when germinated at maturity. Sixty-Day, TS. III-36-9 and O.A.C. 21 had a 4-day dormancy for roughly 10 to 12 days. Regal, at maturity, and for a short period after, resembled the last-mentioned group but was rather sluggish in reaching its complete ability to germinate, and maintained a 2-day dormancy until 52 days after maturity. TC. III-36-46 and Trebi exhibited the greatest reluctance to germinate, the former holding a 6-day dormancy for more than a month after full maturity.

DISCUSSION

After-harvest sprouting is a very real problem in the grain fields of many parts of the world. In Western Canada it is desirable that the breeder take some pains to insure a considerable degree of dormancy in

TABLE 4.—COMPARISON OF EIGHT BARLEY VARIETIES FOR GERMINATION AFTER MATURITY, 1938*

Days after maturity	Days after start of germination test	Germination percentage of varieties							
		Hann.	Rex	60 Day	TC 46	TS 9	Regal	O.A.C. 21	Trebi
0	4	83	60	47	2	31	26	18	11
	6	91	75	63	5	37	40	55	26
	30	95	89	71	38	56	56	86	62
4	4	51	22	35	4	23	24	11	6
	6	80	59	51	6	35	34	27	9
	30	100	97	76	50	68	57	81	68
8	4	89	64	77	6	38	38	73	5
	6	98	88	88	13	49	55	83	9
	30	99	91	92	52	83	71	89	86
12	4	97	78	81	3	48	62	50	10
	6	100	94	90	8	83	73	90	25
	30	100	96	93	59	96	77	97	76
20	2	77	62	65	1	30	24	58	15
	4	99	86	96	6	91	59	93	36
	6	99	90	99	11	95	66	97	47
	30	99	91	99	64	97	68	97	88
36	2	41	39	43	2	37	6	21	9
	4	99	92	97	28	100	63	100	35
	6	99	97	100	35	100	73	100	66
	30	99	99	100	86	100	88	100	90
52	2	37	45	34	0	7	4	5	17
	4	97	90	90	20	86	67	84	49
	6	100	100	99	34	99	92	96	66
	30	100	100	100	83	100	97	97	91
68	2	55	47	48	4	18	35	28	0
	4	100	98	98	24	90	92	95	24
	6	100	100	100	62	100	99	100	61
	30	100	100	100	82	100	100	100	95
84	2	93	86	77	41	36	44	69	45
	4	100	98	100	95	91	93	100	91
	6	100	98	100	98	100	97	100	100
	30	100	98	100	98	100	97	100	100

*NOTE.—Date of maturity was August 6, 1938.

Key to abbreviations in Table 4.

Hann. — Hannchen (Sask. 229)

Rex — Rex (Sask. 1761)

60 Day — Sixty-Day (Sask. 1667)

TC 46 — 1C. III-36-46

TS. 9 — TS. III-36-9

Regal — Regal (Sask. 1865)

O.A.C. 21 — O.A.C. 21 (Sask. 228)

Trebi — Trebi (Sask. 101)

any new grain varieties that are released to the public. The dormancy studies reported in this paper reveal wide differences between varieties and also show that dormancy is not a simple phenomenon.

The varietal reactions ranged from the inability of Reliance to remain dormant for more than 2 days at maturity or thereafter to the ability of Renown to hold a high degree of 30-day dormancy for 2 weeks after maturity. In the barley an equally wide range was apparent, Hannchen possessing practically no dormancy while TC. III-36-46 showed a large amount of 30-day dormancy for 12 days after maturity and high 6-day dormancy for 52 days.

The complexity of dormancy is illustrated by a comparison of the durum wheats with vulgare varieties. The durum varieties possessed no 30-day dormancy at maturity but showed some from 36 to 52 days after maturity, whereas several vulgare varieties showed a large degree of 30-day dormancy at maturity and for 12 days thereafter but none later on. On the other hand the durums had a higher degree of 2-day dormancy 84 days after maturity than did the vulgare varieties, although some of the vulgares held their 2-day dormancy for 52 days.

As some of the barley varieties are related, it is of interest to compare them briefly in this respect. Rex was derived from the cross, Velvex Hannchen, which might explain the similarity between Rex and Hannchen in their reaction to after-ripening. The results on TS. III-36-9 agree with expectation, since that variety is more or less intermediate between its parents, Sixty-Day and Trebi, in its germination characteristics. The same might be stated for TC. III-36-46. Colseess was not tested in this experiment, but Deming and Robertson (1) reported Colseess and Trebi as being similar in their dormancy period, and the results on TC. III-36-46 resemble those on Trebi.

The new stem rust-resistant varieties, Renown, Apex, and Thatcher, proved to have at least as much dormancy as the standard varieties, Marquis and Reward. While it is encouraging to find this favourable degree of dormancy in the new hybrid varieties of wheat, it must be admitted that this situation is to some extent a matter of good luck. Although weathering tests were made on all the new rust-resistant wheats before they were finally chosen for distribution to the public, dormancy as a character did not enter the picture when the original crosses were made.

It is of particular interest that among the new hybrid wheat and barley varieties of Western Canada there are some which excelled such highly satisfactory standard varieties as Marquis and Trebi in their ability to remain dormant under conditions favourable for germination. The plant breeder has a visible basis for constructive work when he recognizes the need for a certain character and has varieties expressing that character.

The paper listed as "Potassium Deficiency in Prunes, Grapes and Clover", by M. E. McCollam, was delivered in the form of an illustrated address and, at the author's suggestion, was not submitted for publication.

The paper on Raspberry Nutrition, by G. H. Harris, read to a joint meeting of the Soils and Horticultural Groups, is printed in this number. Other papers read to the joint meeting of these two groups have been published in the January, 1940, issue of *Scientific Agriculture*, 20: 5.

Professor J. Walker, of the University of Manitoba, was elected Chairman of the Group for 1940. The appointment of a Secretary was left to him. Please address all communications regarding suggestions for the 1940 program to Professor J. Walker.

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1. DEMING, G. W. and D. W. ROBERTSON. Dormancy in small-grain seeds. Col. Agr. College, Fort Collins. Technical Bulletin 5. 1933.
2. FREISTEDT, P. Neue Zielsetzungen in der Gerstenzüchtung. Zeit. Zuchtg. A Pflanzenzüchtg. 20 : 2; 169-209. 1935.
3. HARRINGTON, J. B. The comparative resistance of wheat varieties to sprouting in the stook and windrow. Sci. Agr. 12 : 635-645. 1932.
4. NAVOLOTSKII, A. V. and N. M. NAVOLOTSKAJA. Breeding spring wheat to raise the germination capacity of the grain. Seleksijska i Semenovodstvo (Breeding and Seed Growing). No. 9 : 25-32. 1936. In Russian. English abstract.
5. SCHOLZ, J. The after-ripening of some wheat varieties especially Czechoslovakian. Zvlátní Otisk z Časopisu Vestník Československé Akademie Zemědělské. 9 : 6-7; 403-409. 1933. English summary.

OTHER HORTICULTURAL GROUP PAPERS.

The following papers, read to the Horticultural Group of the Canadian Society of Technical Agriculturists at the Nineteenth Annual Meeting at Vancouver, B.C., June 19 to 22, 1939, have been published in previous issues of Scientific Agriculture.

Blair, D.S., Present status of the apple rootstock and double-working trials in Eastern Canada. Sci. Agr. 20 : 2; 150-154.

Dickson, G. H., Some factors affecting the dropping of McIntosh apples. Sci. Agr. 19 : 12; 712-721.

Hall, E. R., The pollination of the sweet cherry on Vancouver Island, British Columbia. Sci. Agr. 19 : 8; 524-530.

The following papers, while read to the Horticultural Group, have not yet been forwarded for publication.

Root-stock Problems in Western Canada—A. J. Mann and R. C. Palmer.

The Influence of Some Seedling Treatments on Lettuce Production—J. Walker.